

PROJECT MANUAL

ESSER HVAC UPGRADE AT THE FOLLOWING SCHOOL:  
GUILFORD HIGH SCHOOL – RPS#2251

ROCKFORD PUBLIC SCHOOLS 205  
ROCKFORD, ILLINOIS



Owner  
Rockford Public Schools 205  
501 7TH Street  
Rockford, IL 61104

Engineers  
Keith Engineering Design, Inc.  
707 N.E. Jefferson Ave.  
Peoria, IL 61603

IFB 22-32 HVAC Upgrade at One School

KED PROJECT NO. 21-105

Date: February 21, 2022

	Specification Sections:
	Divisions 00, 01, 02, 03, 05, 06, 07, 08, 09, 23, 26
	Signature:
	Name: Ryan C. Reef
	License Number: 062-056761
Expiration Date: 11-21-2023	
Date: 02-11-2022	





[www.kedmep.com](http://www.kedmep.com)

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Peoria, IL : 61603

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## PROJECT MANUAL

### **ESSER HVAC UPGRADES AT THE FOLLOWING SCHOOL:**

(1) GUILFORD HIGH SCHOOL – RPS#2251

501 7<sup>TH</sup> Street, Rockford, IL 61104  
ROCKFORD PUBLIC SCHOOLS 205

FOR

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Illinois Design Firm Registration Number: 184-000000

MEP/FP ENGINEERING

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MARCO SAN ROMAN  
Licensed Architect  
LIC. EXPIRES: 11/30/2022

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RYAN C. REEF  
Registered Professional Engineer  
LIC. EXPIRES: 11/30/2023

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Date

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Date

ESSER HVAC UPGRADES TO GUILFORD HIGH SCHOOL  
ROCKFORD PUBLIC SCHOOLS 205  
ROCKFORD, ILLINOIS

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## BID OFFER FORM

Bid # 22-32 ESSER HVAC UPGRADES GUILFORD HIGH SCHOOL  
for ROCKFORDPUBLIC SCHOOLS DISTRICT 205.

BID SUBMITTED BY: \_\_\_\_\_

Date: February 21, 2022

The undersigned, having become familiar with the local conditions affecting cost of work and with the Bidding Documents, including the advertisement of the Invitation for Bid, the Instructions and Supplementary Instructions to Bidders, this Bid Offer Form, the General and Supplementary Conditions, the Drawings and Specifications, and Addenda issued thereto, as prepared and issued by the Board of Education of Rockford School District No. 205, Winnebago and Boone Counties, Illinois hereby agrees to furnish all labor, material and equipment necessary to do the Work required for the project and IFB identified above, for the amount shown below:

**Note: Contractor to write "No Bid" in the dollar amount section for any line items not bid.**

**BASE BID:**

A. BASE BID:

\_\_\_\_\_ DOLLARS (\$ \_\_\_\_\_)

**ALTERNATE BIDS:**

State the amount to be added to or deducted from the Base Bid when Work shown or specified Under the Alternate Bids is accepted and incorporated in the Contract.

**ALTERNATE BID NO. 1: Heating System Replacement**

Add the sum of:

\_\_\_\_\_ DOLLARS (\$ \_\_\_\_\_).

**ALTERNATE BID NO. 2: Natatorium HVAC System Upgrade**

Add the sum of:

\_\_\_\_\_ DOLLARS (\$ \_\_\_\_\_)

**ALTERNATE BID NO. 3: Field House HVAC Upgrade**

Add the sum of:

\_\_\_\_\_ DOLLARS (\$ \_\_\_\_\_)

## BID OFFER FORM

### **ADDENDA RECEIVED**

The undersigned acknowledges receipt of Addenda\_\_\_\_\_to\_\_\_\_\_inclusive.

### **PRE-BID MEETING ATTENDANCE**

A Bidder representative attended the Pre-Bid Meeting? YES\_\_\_\_\_OR No\_\_\_\_\_.

### **SITE VISIT**

Existing premises and conditions were checked by an on-site inspection on\_\_\_\_\_.

### **CONTRACTOR'S QUALIFICATION STATEMENT**

A fully completed AIA Document A305-1986 Contractor's Qualification Statement is **required** AND MUST BE SUBMITTED WITH THE BID. Include at least three references from projects completed in the past five (5) years with phone number, date of completion, description of work, and project architect (or engineer) contact name with phone number. Projects must be similar to the scope of this bid, and the bidder must have acted in the capacity of prime or general contractor.

Contractor has adequate equipment to perform the work properly and expeditiously:\_\_\_\_Yes\_\_\_\_No.

### **COMMENCEMENT AND COMPLETION OF CONTRACT**

The undersigned agrees, if awarded the Contract, to commence the contract work within five (5) days of receipt of Order to Proceed or if required, upon execution of a formal written contract and to complete said Work within the specified completion time. The undersigned further agrees to execute the Contract, furnish satisfactory performance and payment bond as well as insurance coverage, as specified in strict accordance with the Contract Documents.

Date of Commencement of Construction: June 14, 2022

Date of Substantial Completion: August 6, 2023

Date of Final Completion: August 13, 2023

BIDDER:\_\_\_\_\_  
(Corporation) (Partnership) (Individual) Circle One

Address \_\_\_\_\_  
Street

\_\_\_\_\_  
City State Zip Code

\_\_\_\_\_  
Phone Number Email address

BID OFFER FORM

BIDDER FEIN/SSN \_\_\_\_\_

NO. By: \_\_\_\_\_  
Bidder or Authorized Agent Signature \_\_\_\_\_ Print name \_\_\_\_\_

Title: \_\_\_\_\_

Subscribed and sworn to before this \_\_\_\_\_ day of \_\_\_\_\_, \_\_\_\_\_.

\_\_\_\_\_  
Notary Public

My commission expires: \_\_\_\_\_

BID DEPOSIT CERTIFICATION

A Bid Deposit is required in the amount of 5% of the total Bid including Alternate Bids. This Bid Deposit is to be a Bid Bond, Bank Draft or Certified Check made payable to the "Rockford School District No. 205", as a guarantee that if awarded all or part of the Bid, the firm will enter into a contract to perform with the Board of Education.

Amount of Total Bid \$ \_\_\_\_\_

Amount of Bank draft or Certified Check \$ \_\_\_\_\_

BIDDER: \_\_\_\_\_

\_\_\_\_\_  
Signature of Bidder or Authorized Agent

**SUBCONTRACTOR LISTING**

1. Pursuant to bidding requirements for the Work:  
The Bidder, for portions of the Work equaling or exceeding 1/2 of 1% of the total Contract Sum, proposes to use the following Subcontractors. The Bidder proposes to perform all other portions of the Work with its own forces. The District reserves the right to qualify all Subcontractors. COPY AND ATTACH ADDITIONAL SHEETS AS NECESSARY.

2. <u>Portion of the Work</u>	<u>Subcontractor Name and Address</u>
_____	_____
_____	_____
_____	_____
_____	_____



**SECTION 00 7300**

**SUPPLEMENTARY CONDITIONS**

1. CHANGE ORDER MARK-UPS: Add the following to provisions regarding Change Order markups in the Conditions of the Contract:
  - A. The combined overhead and profit included in the total cost to the Owner for a change in the Work shall be based on the following schedule:
    - .1 For the Contractor, for Work performed by the Contractor's own forces, twelve percent (12%) of the cost.
    - .2 For the Contractor, for Work performed by the Contractor's Subcontractors, five percent (5%) of the amount due the Subcontractors.
    - .3 For each Subcontractor involved, for Work performed by that Subcontractor's own forces, twelve percent (12%) of the cost.
    - .4 For each Subcontractor involved, for Work performed by the Subcontractor's Subcontractors, five percent (5%) of the amount due the Sub-subcontractor.
    - .5 In order to facilitate checking of quotations for extras or credits, all proposals, except those so minor that their propriety can be seen by inspection, shall be accompanied by a complete itemization of costs including labor, materials and Subcontracts. Labor and materials shall be itemized in the manner prescribed above. Where major cost items are Subcontracts, they shall be itemized also.

**END OF DOCUMENT 00 7300**



**SECTION 01 1000**

**SUMMARY**

**PART 1 - GENERAL**

**1.1 SUMMARY OF WORK**

- A. Project: HVAC Upgrades at Guilford High School.
- B. Owner: Rockford Public Schools District 205.
- C. The Work includes but is not limited to the following:
  - 1. HVAC Upgrades.
  - 2. New Penthouse
- D. Work Under Other Contracts:
  - 1. General: Cooperate fully with separate contractors so work on those contracts may be carried out smoothly, without interfering with or delaying work under this Contract or other contracts. Coordinate the Work of this Contract with work performed under separate contracts.

**1.2 WORK RESTRICTIONS**

- A. Contractor's Use of Premises: During construction, Contractor will have limited use of site and building indicated.
  - 1. Owner will occupy premises during construction. Perform construction during normal working hours (7 AM to 4 PM Monday thru Friday, other than holidays), unless otherwise agreed to in advance by Owner. Clean up work areas and return to a useable condition at the end of each work period.

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

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

**END OF SECTION 01 1000**





**SECTION 01 2000**

**PRICE AND PAYMENT PROCEDURES**

**PART 1 - GENERAL**

**1.1 ALLOWANCES**

- A. Allowances shall include cost to Contractor of specific products and materials ordered by Owner under allowance and shall include taxes, freight, and delivery to Project site. Allowances are specified in the Bid Form.
- B. Obtain three proposals for each allowance and submit to Architect with recommendations. Purchase products and systems selected by Owner.
- C. Advise Architect of the date when selection and purchase of each product or system described by an allowance must be completed to avoid delaying the Work.
- D. Submit invoices to show cost of products furnished under each allowance. Reconciliation of Allowance amounts with actual costs will be by Change Order.

**1.2 ALTERNATES**

- A. An alternate is an amount proposed by bidder for certain work that may be added to or deducted from the Base Bid amount if Owner accepts the Alternate. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate the Alternate into the Work. No other adjustments are made to the Contract Sum. B. Alternates are specified in the Bid Form.

**1.3 UNIT PRICES**

- A. A unit price is an amount proposed by bidders and stated on the Bid Form as a price per unit of measurement for work added to or deducted from the Contract Sum by appropriate modification, if estimated quantities of Work required by the Contract Documents are increased or decreased. Unit prices are specified in the Bid Form.
- B. Unit prices include all necessary material, plus cost for delivery, installation, insurance, overhead, and profit.

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

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

**END OF SECTION 01 2000**



**SECTION 01 3000**

**ADMINISTRATIVE REQUIREMENTS**

**PART 1 - GENERAL**

**1.1 PROJECT MANAGEMENT AND COORDINATION**

- A. Coordinate construction to ensure efficient and orderly installation of each part of the Work.
- B. Schedule and conduct progress meetings at Project site at regular intervals. Notify Owner and Architect of meeting dates and times. Require attendance of each subcontractor or other entity concerned with current progress or involved with planning or coordination of future activities.
  - 1. Record minutes and distribute to everyone concerned, including Owner and Architect.

**1.2 SUBMITTAL PROCEDURES**

- A. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
  - 1. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
  - 2. Prepare submittals as PDF packages and transmit to Architect by email.
    - 1 Email Address: [submittals@kedmep.com](mailto:submittals@kedmep.com).
    - 2 Architect will annotate PDF submittal and return.
  - 3. Architect will return submittals, without review, received from sources other than Contractor.
- B. Place a permanent label or title block on each submittal for identification. Provide a space approximately 6 by 8 inches on label or beside title block to record Contractor's review and approval markings and action taken by Architect. Include the following information on the label:
  - 1. Project name.
  - 2. Date.
  - 3. Name and address of Contractor.
  - 4. Name and address of subcontractor or supplier.
  - 5. Number and title of appropriate Specification Section.
- C. Identify deviations from the Contract Documents on submittals.
- D. Contractor's Construction Schedule Submittal Procedure: Submit two copies of schedule within 10 working days after date established for Commencement of the Work.

**PART 2 - PRODUCTS**

**2.1 ACTION SUBMITTALS**

- A. Product Data: Mark each copy to show applicable products and options. Include the following:
  - 1. Manufacturer's written recommendations, product specifications, and installation instructions.
  - 2. Testing by recognized testing agency.
  - 3. Compliance with specified standards and requirements.

- B. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data. Submit on sheets at least 8-1/2 by 11 inches but no larger than 30 by 42 inches. Include the following:
  - 1. Dimensions and identification of products.
  - 2. Fabrication and installation drawings and roughing-in and setting diagrams.
- C. Samples: Submit Samples for review of kind, color, pattern, and texture and for a comparison of these characteristics between submittal and actual component as delivered and installed. Include name of manufacturer and product name on label.
  - 1. If variation is inherent in material or product, submit at least three sets of paired units that show variations.

## **2.2 INFORMATION SUBMITTALS**

- A. Qualification Data: Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.
- B. Product Certificates: Prepare written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

## **2.3 DELEGATED DESIGN**

- A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
  - 1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.
- B. Delegated-Design Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit three copies of a statement, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
  - 1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

## **2.4 CONTRACTOR'S CONSTRUCTION SCHEDULE**

- A. Gantt-Chart Schedule: Submit a comprehensive, fully developed, horizontal Gantt-chart-type schedule within 10 days of date established for the Notice of Award.
- B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line.

# **PART 3 - EXECUTION**

## **3.1 SUBMITTAL REVIEW**

- A. Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.
- B. Architect will review each action submittal, make marks to indicate corrections or modifications required, stamp and mark as appropriate to indicate action taken, and return.

### **3.2 CONTRACTOR'S CONSTRUCTION SCHEDULE**

- A. Distribute copies of approved schedule to Owner, Architect, subcontractors, testing and inspecting agencies, and parties identified by Contractor with a need-to-know schedule responsibility. When revisions are made, distribute updated schedules to the same parties.
- B. Updating: At monthly intervals, update schedule to reflect actual construction progress and activities.
  - 1. As the Work progresses, indicate Actual Completion percentage for each activity.

**END OF SECTION 01 3000**



**SECTION 01 5000**

**TEMPORARY FACILITIES AND CONTROLS**

**PART 1 - GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. Use Charges: Cost or use charges for temporary facilities shall be included in the Contract Sum.
- B. Use water and electric power from Owner's existing system without metering and without payment of use charges.
- C. Electrical Service: Comply with NEMA, NECA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

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

**PART 3 - EXECUTION**

**3.1 TEMPORARY UTILITIES**

- A. Sanitary Facilities: Contractor may use existing toilets when the building is not occupied by students.

**3.2 TEMPORARY SUPPORT FACILITIES**

- A. Provide waste-collection containers in sizes adequate to handle waste from construction operations. Collect waste daily and, when containers are full, legally dispose of waste off-site. Comply with requirements of authorities having jurisdiction.
- B. Install project identification and other signs in locations approved by Owner to inform the public and persons seeking entrance to Project.

**3.3 TEMPORARY SECURITY AND PROTECTION FACILITIES**

- A. Provide temporary environmental protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.
- B. Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.

**END OF SECTION 01 5000**





**SECTION 01 6000**

**PRODUCT REQUIREMENTS**

**PART 1 - GENERAL**

**1.1 SECTION REQUIREMENTS**

- A. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.
- B. Product Substitutions: Substitutions include changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor after award of the Contract.
  - 1. Submit three copies of each request for product substitution.
  - 2. Submit requests within ten days after the Notice of Award.
  - 3. Do not submit unapproved substitutions on Shop Drawings or other submittals.
  - 4. Identify product to be replaced and show compliance with requirements for substitutions. Include a detailed comparison of significant qualities of proposed substitution with those of the Work specified, a list of changes needed to other parts of the Work required to accommodate proposed substitution, and any proposed changes in the Contract Sum or the Contract Time should the substitution be accepted.
  - 5. Architect will review the proposed substitution and notify Contractor of its acceptance or rejection.
- C. Comparable Product Requests:
  - 1. Submit three copies of each request for comparable product. Do not submit unapproved products on Shop Drawings or other submittals.
  - 2. Identify product to be replaced and show compliance with requirements for comparable product requests. Include a detailed comparison of significant qualities of proposed substitution with those of the Work specified.
  - 3. Architect will review the proposed product and notify Contractor of its acceptance or rejection.
- D. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with manufacturer's written instructions.
  - 1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.
  - 2. Deliver products to Project site in manufacturer's original sealed container or packaging, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
  - 3. Inspect products on delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.
  - 4. Store materials in a manner that will not endanger Project structure.
  - 5. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
- E. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.

## **PART 2 - PRODUCTS**

### **2.1 PRODUCT OPTIONS**

- A. Provide products that comply with the Contract Documents, are undamaged, and are new at the time of installation.
  - 1. Provide products complete with accessories, trim, finish, and other devices and components needed for a complete installation and the intended use and effect.
  - 2. Descriptive, performance, and reference standard requirements in the Specifications establish "salient characteristics" of products.
- B. Product Selection Procedures:
  - 1. Where Specifications name a single product or manufacturer, provide the item indicated that complies with requirements, or Owner-approved equal.
  - 2. Where Specifications include a list of names of products or manufacturers, provide one of the items indicated that complies with requirements, or Owner-approved equal.
  - 3. Where Specifications include a list of names of products or manufacturers, accompanied by the term "available products" or "available manufacturers," provide one of the named items that complies with requirements, or Owner-approved equal. Comply with provisions for "comparable product requests" for consideration of an unnamed product.
  - 4. Where Specifications name a product as the "basis-of-design" and include a list of manufacturers, provide the named product, or Owner-approved equal. Comply with provisions for "comparable product requests" for consideration of an unnamed product by the other named manufacturers.
  - 5. Where Specifications name a single product as the "basis-of-design" and no other manufacturers are named, provide the named product or Owner-approved equal. Comply with provisions for "comparable product requests" for consideration of an unnamed product by another manufacturer.
- C. Unless otherwise indicated, Architect will select color, pattern, and texture of each product from manufacturer's full range of options that includes both standard and premium items.

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

**END OF SECTION 01 6000**

## **SECTION 01 7000**

### **EXECUTION AND CLOSEOUT REQUIREMENTS**

#### **PART 1 - GENERAL**

##### **1.1 CLOSEOUT SUBMITTALS**

- A. Record Drawings: Maintain a set of prints of the Contract Drawings as Record Drawings. Mark to show actual installation where installation varies from that shown originally.
  - 1. Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.
- B. Operation and Maintenance Data: Submit one copy of manual. Organize data into three-ring binders with identification on front and spine of each binder, and envelopes for folded drawings. Include the following:
  - 1. Manufacturer's operation and maintenance documentation.
  - 2. Video on CD or flashdrive of training seminar for Owner use.
  - 3. Maintenance and service schedules.
  - 4. Maintenance service contracts.
  - 5. Emergency instructions.
  - 6. Spare parts list.
  - 7. Copies of warranties.

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

#### **PART 3 - EXECUTION**

##### **3.1 EXAMINATION AND PREPARATION**

- A. Examine substrates and conditions for compliance with manufacturer's written requirements including, but not limited to, surfaces that are sound, level, plumb, smooth, clean, and free of deleterious substances; substrates within installation tolerances; and application conditions within environmental limits. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Before proceeding to lay out the Work, verify layout information shown on Drawings.
- C. Take field measurements as required to fit the Work properly. Where fabricated products are to be fitted to other construction, verify dimensions by field measurement before fabrication and, when possible, allow for fitting and trimming during installation.

##### **3.2 CUTTING AND PATCHING**

- A. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.
  - 1. Structural Elements: When cutting and patching structural elements, notify Architect of locations and details of cutting and await directions from Architect before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

2. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.
  3. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety.
  4. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
- B. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.
- C. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.
- D. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, using methods least likely to damage elements retained or adjoining construction. .
1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
  2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
  3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
  4. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
  5. Proceed with patching after construction operations requiring cutting are complete.
- E. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements specified in other Sections, where applicable.
1. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will minimize evidence of patching and refinishing.
  2. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
  3. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
  4. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition and ensures thermal and moisture integrity of building enclosure.

### **3.3 INSTALLATION**

- A. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment,

and systems.

- B. Comply with manufacturer's written instructions for installation. Anchor each product securely in place, accurately located and aligned with other portions of the Work. Clean exposed surfaces and protect from damage.
- C. Clean Project site and work areas daily, including common areas.

### **3.4 FINAL CLEANING**

- A. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion:
  - 1. Remove labels that are not permanent.
  - 2. Clean exposed finishes to a dust-free condition, free of stains, films, and foreign substances. Sweep concrete floors broom clean.
  - 3. Vacuum clean floors in areas of Work.
  - 4. Wipe surfaces of mechanical and electrical equipment. Remove excess lubrication. Clean plumbing fixtures. Clean light fixtures, lamps, globes, and reflectors.
  - 5. Clean Project site, yard, and grounds, in areas disturbed by construction activities. Sweep paved areas; remove stains, spills, and foreign deposits. Rake grounds to a smooth, even-textured surface.

### **3.5 CLOSEOUT PROCEDURES**

- A. Substantial Completion: Before requesting Substantial Completion inspection, complete the following:
  - 1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
  - 2. Advise Owner of pending insurance changeover requirements.
  - 3. Submit specific warranties, maintenance service agreements, and similar documents.
  - 4. Obtain and submit releases permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
  - 5. Submit Record Drawings and Specifications, operation and maintenance manuals, and Similar final record information.
  - 6. Deliver tools, spare parts, extra materials, and similar items.
  - 7. Complete final cleaning requirements.
  - 8. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- B. Submit a written request for inspection for Substantial Completion. On receipt of request, Architect will proceed with inspection or advise Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will advise Contractor of items that must be completed or corrected before certificate will be issued. C. Request inspection for Final Completion, once the following are complete:
  - 1. Submit a copy of Substantial Completion inspection list stating that each item has been completed or otherwise resolved for acceptance.
- C. Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.

- D. Submit a written request for final inspection for acceptance. On receipt of request, Architect will proceed with inspection or advise Contractor of unfulfilled requirements. Architect will prepare final Certificate for Payment after inspection or will advise Contractor of items that must be completed or corrected before certificate will be issued.

### **3.6 DEMONSTRATION AND TRAINING**

- A. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system. Include a detailed review of the following:
  - 1. Include instruction for basis of system design and operational requirements, review of documentation, emergency procedures, operations, adjustments, troubleshooting, maintenance, and repairs.

**END OF SECTION 01 7000**

**SECTION 01 7823**

**OPERATION AND MAINTENANCE DATA**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
  - 1. Operation and maintenance documentation directory.
  - 2. Emergency manuals.
  - 3. Operation manuals for systems, subsystems, and equipment.
  - 4. Product maintenance manuals.

**1.2 CLOSEOUT SUBMITTALS**

- A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.
  - 1. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.
- B. Format: Submit operations and maintenance manuals in the following format:
  - 1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Owner.
    - a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.
    - b. Enable inserted reviewer comments on draft submittals.
  - 2. Three paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Owner will return two copies.
- C. Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Owner will return copy with comments.
  - 1. Correct or revise each manual to comply with Owner's comments. Submit copies of each corrected manual within 15 days of receipt of Owner's comments and prior to commencing demonstration and training.

**PART 2 - PRODUCTS**

**2.1 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS**

- A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information.
- B. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:
  - 1. Title page.
  - 2. Table of contents.
  - 3. Manual contents.

- C. Title Page: Include the following information:
  - 1. Subject matter included in manual.
  - 2. Name and address of Project.
  - 3. Name and address of Owner.
  - 4. Date of submittal.
  - 5. Name and contact information for Contractor.
  - 6. Name and contact information for Architect.
  - 7. Names and contact information for major consultants to the Owner that designed the systems contained in the manuals.
  - 8. Cross-reference to related systems in other operation and maintenance manuals.
- D. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
- E. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
- F. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.
  - 1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
  - 2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.
- G. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.
  - 1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
    - a. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
  - 2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
  - 3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
  - 4. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
    - a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
    - b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.



## **2.2 EMERGENCY MANUALS**

- A. Content: Organize manual into a separate section for each of the following:
  - 1. Type of emergency.
  - 2. Emergency instructions.
  - 3. Emergency procedures.
- B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:
  - 1. Fire.
  - 2. Flood.
  - 3. Gas leak.
  - 4. Water leak.
  - 5. Power failure.
  - 6. Water outage.
  - 7. System, subsystem, or equipment failure.
  - 8. Chemical release or spill.
- C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.
- D. Emergency Procedures: Include the following, as applicable:
  - 1. Instructions on stopping.
  - 2. Shutdown instructions for each type of emergency.
  - 3. Operating instructions for conditions outside normal operating limits.
  - 4. Required sequences for electric or electronic systems.
  - 5. Special operating instructions and procedures.

## **2.3 OPERATION MANUALS**

- A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:
  - 1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
  - 2. Performance and design criteria if Contractor is delegated design responsibility.
  - 3. Operating standards.
  - 4. Operating procedures.
  - 5. Operating logs.
  - 6. Wiring diagrams.
  - 7. Control diagrams.
  - 8. Piped system diagrams.
  - 9. Precautions against improper use.
  - 10. License requirements including inspection and renewal dates.
- B. Descriptions: Include the following:
  - 1. Product name and model number. Use designations for products indicated on Contract Documents.
  - 2. Manufacturer's name.
  - 3. Equipment identification with serial number of each component.
  - 4. Equipment function.

5. Operating characteristics.
  6. Limiting conditions.
  7. Performance curves.
  8. Engineering data and tests.
  9. Complete nomenclature and number of replacement parts.
- C. Operating Procedures: Include the following, as applicable:
1. Startup procedures.
  2. Equipment or system break-in procedures.
  3. Routine and normal operating instructions.
  4. Regulation and control procedures.
  5. Instructions on stopping.
  6. Normal shutdown instructions.
  7. Seasonal and weekend operating instructions.
  8. Required sequences for electric or electronic systems.
  9. Special operating instructions and procedures.
- D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
- E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

## **2.4 PRODUCT MAINTENANCE MANUALS**

- A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.
- B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Product Information: Include the following, as applicable:
1. Product name and model number.
  2. Manufacturer's name.
  3. Color, pattern, and texture.
  4. Material and chemical composition.
  5. Reordering information for specially manufactured products.
- D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
1. Inspection procedures.
  2. Types of cleaning agents to be used and methods of cleaning.
  3. List of cleaning agents and methods of cleaning detrimental to product.
  4. Schedule for routine cleaning and maintenance.
  5. Repair instructions.
- E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

- F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

## **2.5 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS**

- A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
- B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
  - 1. Standard maintenance instructions and bulletins.
  - 2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
  - 3. Identification and nomenclature of parts and components.
  - 4. List of items recommended to be stocked as spare parts.
- D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
  - 1. Test and inspection instructions.
  - 2. Troubleshooting guide.
  - 3. Precautions against improper maintenance.
  - 4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
  - 5. Aligning, adjusting, and checking instructions.
  - 6. Demonstration and training video recording, if available.
- E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
- F. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
- G. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

## **PART 3 - EXECUTION**

### **3.1 MANUAL PREPARATION**

- A. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

- B. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.
- C. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.
- D. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.
- E. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.
  - 1. Do not use original project record documents as part of operation and maintenance manuals.

**END OF SECTION 01 7823**

## **SECTION 01 7839**

### **PROJECT RECORD DOCUMENTS**

#### **PART 1 - GENERAL**

##### **1.1 SUMMARY**

- A. Section includes administrative and procedural requirements for project record documents, including the following:
  - 1. Record Drawings.
  - 2. Record Specifications.
  - 3. Record Product Data.
- B. Related Requirements:
  - 1. Section 01 78 23 "Operation and Maintenance Data" for operation and maintenance manual requirements.

##### **1.2 CLOSEOUT SUBMITTALS**

- A. Record Drawings: Comply with the following:
  - 1. Number of Copies: Submit copies of record Drawings as follows:
    - a. Initial Submittal:
      - 1) Submit PDF electronic files of scanned record prints and one set(s) of file prints.
      - 2) Owner will indicate whether general scope of changes, additional information recorded, and quality of drafting are acceptable.
    - b. Final Submittal:
      - 1) Submit PDF electronic files of scanned record prints and one set(s) of prints.
      - 2) Print each drawing, whether or not changes and additional information were recorded.
- C. Record Specifications: Submit one paper copy and annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.
- D. Record Product Data: Submit one paper copy and annotated PDF electronic files and directories of each submittal.

#### **PART 2 - PRODUCTS**

##### **2.2 RECORD DRAWINGS**

- A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised Drawings as modifications are issued.
  - 1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.
    - a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
    - b. Record data as soon as possible after obtaining it.
    - c. Record and check the markup before enclosing concealed installations.
  - 2. Mark the Contract Drawings and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.

3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
  4. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.
- B. Record Digital Data Files: Immediately before inspection for Certificate of Substantial Completion, review marked-up record prints with Owner. When authorized, prepare a full set of corrected digital data files of the Contract Drawings, as follows:
1. Format: Annotated PDF electronic file with comment function enabled.
  2. Incorporate changes and additional information previously marked on record prints. Delete, redraw, and add details and notations where applicable.
  3. Refer instances of uncertainty to Owner for resolution.
- C. Format: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.
1. Record Prints: Organize record prints and newly prepared record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
  2. Format: Annotated PDF electronic file with comment function enabled.
  3. Record Digital Data Files: Organize digital data information into separate electronic files that correspond to each sheet of the Contract Drawings. Name each file with the sheet identification. Include identification in each digital data file.
  4. Identification: As follows:
    - a. Project name.
    - b. Date.
    - c. Designation "PROJECT RECORD DRAWINGS."
    - d. Name of Owner.
    - e. Name of Contractor.

## **2.3 RECORD SPECIFICATIONS**

- A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
  2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
  3. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.
  4. Note related Change Orders, record Product Data, and record Drawings where applicable.
- B. Format: Submit record Specifications as annotated PDF electronic file.

## **2.4 RECORD PRODUCT DATA**

- A. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.
1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
  2. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.
  3. Note related Change Orders, record Specifications, and record Drawings where applicable.
- B. Format: Submit record Product Data as annotated PDF electronic file.

## **2.5 MISCELLANEOUS RECORD SUBMITTALS**

- A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.
- B. Format: Submit miscellaneous record submittals as PDF electronic file.

## **PART 3 - EXECUTION**

### **3.1 RECORDING AND MAINTENANCE**

- A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project.
- B. Maintenance of Record Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to project record documents for Owner's reference during normal working hours.

**END OF SECTION 01 7839**





**SECTION 02 4119  
SELECTIVE DEMOLITION**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of work shown on the drawings and/or specified in this section.

**1.2 SCOPE OF WORK**

- A. Work included under this section shall include but not necessarily be limited to the following:
  - 1. Perform demolition work as necessary to accomplish the work, including the removal and proper disposal of items which are exposed and not to remain in use, including but not necessarily limited to pavement, walks, plantings, foundations, slabs, structural items, walls, roofing, flashings, doors, frames, windows, curtain wall, glazing, finishes, ceilings, flooring, framing, trim, specialties, equipment, casework, plumbing, mechanical and electrical items, etc.
  - 2. Include items exposed such as sewer, water and electrical lines which may require capping per city or utility company requirements.
  - 3. Properly dispose of demolished material and such other obstacles required for a complete and proper installation of new work and the disposition of materials incidental to this work.
  - 4. Erection of barricades, etc., to protect existing building areas.
  - 5. Protection of existing utilities.
  - 6. Repair to building areas, utilities damaged during demolition.
  - 7. Demolition in specific building locations to the extent described on the drawings and/or required to construct the work shown.
  - 8. Remove protection when work is complete.
  - 9. Rubbish and debris shall be promptly removed from building as to minimize dust within the building.
  - 10. Coordinate with Owner Operations. Portions of the school building will be in operation during the construction phase.
- B. Existing surfaces and finishes which are marred or defaced as a result of demolition work shall be patched and matched as required.
- C. Demolition shall include the removal of debris materials associated with demolition procedures. Debris shall be properly deposited into project dumpsters and subsequently taken to a legal dump site.

**1.3 JOB CONDITIONS**

- A. Visit the site and be informed as to the character and type of work to be removed. Owner assumes no responsibility for the condition of existing construction to be removed or demolished. Later claims for additional payment for conditions reasonably foreseeable

shall not be allowed.

#### **1.4 PROTECTION**

- A. Provide and maintain, during demolition operations, barricades and temporary environmental protection to separate the working area from other areas.
- B. Remove protections and temporary enclosures when work is complete.
- C. Properly protect existing building, walks, paving, grass, trees, shrubs, etc. Properly restore/replace damaged items meeting Owner approval.
- D. Where demolition operations create conditions which may result in water and/or weather leaks, provide necessary temporary enclosures which create a weathertight barrier and protect existing structures and facilities from damage due to infiltration of water and/or weather.
- E. Verify routing of existing Fire Alarm, Electrical, Security, Phone, Mechanical, Plumbing, and other systems prior to cutting roof, walls, floor, etc. Maintain these systems in full operating condition during course of the work. Pay repair costs to systems and finishes damaged during the execution of the Work.

#### **1.5 DEMOLITION**

- A. Exact extent of demolition as shown on drawings and to be completed shall be verified at the site. Determine the nature and extent of demolition that will be necessary by comparing the drawings with existing site conditions. Operations shall be done in a careful and orderly manner to avoid hazards to persons and property, and interference with the use of adjacent areas, and interruption of free passage to and from such areas.
- B. Where concrete or masonry is to be cut, a straight cut line shall be obtained by using a carborundum masonry saw.
- C. Work shall be demolished in small sections. Provide bracing and shoring necessary to maintain existing building integrity.
- D. Do not remove more of existing construction than is necessary. Do not mar, damage, or deface construction which is to remain.
- E. Verify routing of existing Fire Alarm, Electrical, Security, Phone, Mechanical, Plumbing, and other systems prior to cutting roof, walls, floor, etc. Maintain these systems in full operating condition during course of the work. Pay repair costs to systems and finishes damaged during the execution of the Work.
- F. Access routes to and from the site shall be kept clean of debris resulting from the Work.

#### **1.6 SALVAGEABLE ITEMS**

- A. Verify with the Owner the items to be salvaged and turned over to the Owner.

**END OF SECTION 02 4119**

**SECTION 03 1500**

**CONCRETE ACCESSORIES**

**PART 1 – GENERAL**

**1.1 DESCRIPTION**

A. Work specified under this Section includes:

1. Joint Fillers
2. Sealant

**1.2 SUBMITTALS**

A. Samples and Certifications:

1. Samples and certifications for all materials shall be submitted to the Engineer.

**PART 2 – PRODUCTS**

**2.1 JOINT FILLERS**

A. Preformed bituminous fiber joint filler shall be non-extruding type conforming to ASTM D1751. Joint fillers shall be not less than 1/2" thick.

**2.2 JOINT SEALANT**

- A. Sealant shall be two component, polysulfide base, chemical curing, ASTM C920, Type M, Grade P or NS, class 25, capable of being continuously immersed in water. As manufactured by W.R Meadows, CM-60, 2-part, or Sonneborn Sonolastic, 2-part.
- B. Carry out application and mixing procedures in accordance with manufacturer's recommendations. Bond breaker shall be used to separate the sealant from the preformed or existing joint filler.
- C. Bond breaker shall be polyethylene tape with adhesive for attachment to preformed joint filler.

**PART 3 – EXECUTION**

**3.1 CONSTRUCTION JOINTS**

- A. No horizontal construction joints will be permitted in slabs, beams or girders.
- B. Vertical joints in reinforced slabs, beams or girders shall be perpendicular to the axis or plane of the members joined.
- C. Construction joints in addition to those shown on the Drawings are prohibited.

**3.2 PAYMENT**

- A. The cost of this work shall be considered incidental to the contract lump sum price for the project.

**END SECTION 03 1500**



**SECTION 03 3000**

**CAST-IN-PLACE CONCRETE**

**PART 1 – GENERAL**

**1.1 WORK INCLUDES**

- A. Provide concrete work shown and specified for:
- B. Concrete mixtures, mixing, transporting, placement, curing, and finishing of concrete footings, walls, slabs, and floors.

**1.2 SUBMITTALS**

- A. Product Data:
  - 1. Submit concrete mix design per ACI 301 requirements.
  - 2. Material certifications for form materials, release agents, steel reinforcing, curing compounds, bonding agents, joint fillers, and repair materials.
- B. Certifications and Samples:
  - 1. Submit certifications from manufacturers that materials or products meet specification requirements.

**1.3 QUALITY CONTROL**

- a. Work on this project shall conform to all requirements of ACI 301 'Specifications for Structural Concrete' published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents.
- B. Materials and Methods:
  - 1. Materials and Methods of mixing and placing concrete shall conform to ACI 318, Building Code Requirements for Reinforced Concrete.
- C. Laboratory Testing:
  - 1. The Contractor will retain the services of a testing laboratory and pay all laboratory costs to make tests and submit reports. All additional tests required because concrete fails to meet Specification shall also be paid by the Contractor.
  - 2. The Contractor shall provide all necessary labor and devices to obtain samples and provide field curing.
  - 3. The testing laboratory will provide for inspection of the concrete batch plant to see that the concrete is properly mixed and the consistency of mix is being controlled.
  - 4. The laboratory will immediately submit two copies of laboratory reports on all strength tests to the Engineer. Reports will be made on a form acceptable to the Engineer and will indicate delivery ticket numbers, strength, slump, air entrainment, admixtures, concrete temperature, pour location, date, age, density, outdoor air temperature and remarks on property changes. Slump tests are not required for super plasticized concrete.
- D. Compressive Strength Tests:
  - 1. Sample specimens for strength tests of concrete shall be taken not less than once a day, nor less than once for each 50 cubic yards of concrete placed, nor less than once for each 5000 square feet of surface area for slabs and/or walls. Five specimens shall be secured in accordance with ASTM C172. Three specimens will be laboratory-cured in accordance with ASTM C31. The other two shall be cured entirely under field conditions. Compressive strength tests will be made at the age of 7 days on one-field cured and one

laboratory-cured specimen. Compressive strength tests will be made at the age of 28 days on one field-cured and one laboratory- cured specimen. The fifth specimen shall be tested at such time as directed by the Engineer. All tests will be in compliance with ASTM C39.

2. If any specimen test falls below the specified strength, the Architect/ Engineer will determine the appropriate corrective measures to be provided at the Contractor's expense. Test failure can constitute sufficient reason for the Engineer to direct the Contractor to remove all parts of a structure or structural element.

E. Slump Tests:

1. One test for slump per truckload will be made in accordance with ASTM C143, except no test is required for super plasticized concrete.

F. Air Entrainment Tests:

1. One air content test per truckload will be made. The air content tests will be made in accordance with ASTM C138, C173, C231, or AASHTO I-152.

#### **1.4 ADVERSE WEATHER CONDITIONS**

- A. Comply with ACI 305 or 306 for hot or cold weather concreting.
- B. Maintain the temperature of concrete above 50°F for not less than 5 days after placement. Transition the concrete to the outside temperature at a rate of 1°F each hour.
- C. In no case shall the temperature of concrete exceed 90°F. If insulated forms are used, the temperature of the concrete mixture shall not exceed 80°F. Temperatures exceeding these values shall constitute batch rejection.

### **PART 2 – PRODUCTS**

#### **2.1 CONCRETE MATERIALS**

A. Water:

1. Water shall be clean and potable.

B. Cement:

1. Portland Cement shall be ASTM C150 Type I.

C. Aggregate:

1. Fine and coarse aggregate shall be clean, hard, natural, or manufactured material conforming to ASTM C33, with maximum size shall be 3/4-inch.

D. Admixtures:

1. Admixtures shall conform to ASTM C260 (air entrainment) or C494 (water reduction) and shall be products of one of the following manufacturers:
  - a. Dewey and Almy Chemical Division., W.R. Grace and Company
  - b. Euclid Chemical Company
  - c. Master Builders Company
  - d. Sika Chemical Corporation

#### **2.2 REBAR**

- A. Deformed Reinforcing Bars: ASTM A615, grade 60.
- B. Bar supports per CRSI's "Manual of Standard Practice".

## **2.3 MISCELLANEOUS MATERIALS**

### **A. Vapor Barrier:**

1. Vapor barrier shall be polyethylene film 0.006 inches thick and shall conform to Product Standard PS-17.

### **B. Membrane Curing Compound: ASTM C309**

### **C. Waterproofing and Corrosion Protection Materials**

## **2.4 GROUT AND MORTAR MIXTURES**

### **A. High Strength Grout:**

1. High Strength grout shall be a premixed, nonferrous, shrinkage-compensating cementitious mixture with a 28-day strength of at least 6000 psi.

### **B. Patching Mortar:**

1. Mix one part portland cement to 3 parts fine aggregate. Add white cement to match color of adjacent surface. Mix with minimum amount of water necessary.

## **2.5 CONCRETE MIXTURES**

### **A. Concrete:**

1. Minimum 7-day compressive strength = 3,000 psi
2. Minimum 28-day compressive strength = 4,000 psi
3. Air entrainments shall be 4% to 7%
4. Maximum aggregate size = 3/4 inches.
  - a. Course aggregate content = 1,680 pounds per cubic yard
  - b. Fine aggregate content = 1,430 pounds per cubic yard
5. Superplasticizer shall be added to increase slump to a range of 60 to 80 and may be redosed.
6. Accelerating admixtures are prohibited.
7. Maximum water/cementitious material ratio = 0.42.
  - a. Cement content = 450 pounds per cubic yard.
  - b. Class C Fly Ash content = 120 pounds per cubic yard.
  - c. Site addition of water is prohibited.

### **B. Admixtures:**

1. Water-reducing admixture added to concrete shall reduce the water-cement ratio while maintaining slump and compressive strength. Use as manufacturer recommends.
2. Calcium chloride and admixtures containing any form of chloride are prohibited.
3. The superplasticizer shall be dosed and used in strict accordance with the manufacturer's recommendations. The superplasticizer shall be chloride free.

## **PART 3 – EXECUTION**

### **3.1 PREPARATIONS**

#### **A. Subgrade Preparation:**

1. The subgrade and/or bedding shall be compacted and free of frost. Placement will not be allowed at temperatures below 40° F. Saturate the subgrade approximately 8 hours before placement and sprinkle ahead of the placement of concrete in areas where vapor barrier is not used. Remove all standing water, ice, mud, and foreign matter before concrete is deposited. Mud slabs shall be provided where necessary to obtain a dry and stable working platform for placement of slabs. Excavations shall be cleaned by hand prior to placement of concrete.
- B. Vapor Barrier:
1. Provide vapor barrier for all slabs on grade. Lay vapor barrier sheets with 6-inch edge laps and tape or seal with mastic. Stretch and weigh edges and laps to maintain their positions until concrete is placed.

### **3.2 MIXING AND TRANSPORTING CONCRETE**

- A. Concrete shall be ready-mixed or job-mixed at each Contractor's option. Ready-mixed concrete shall be mixed and delivered to the project in accordance with ASTM C94. Job-mixed concrete shall be in accordance with the requirements of ACI 318.
- B. Concrete shall be in its final position within one hour after the water and/or aggregate have been added to the cement.
- C. Concrete shall be transported from the mixer to place of final deposit in such manner to prevent separation or loss of ingredients.

### **3.3 DEPOSITING CONCRETE**

- A. General:
1. Concrete shall be placed in accordance with the requirements of ACI 318 and within 10 feet of its final position. Place concrete only during normal working hours unless the Engineer is notified at least 24 hours in advance. Concrete shall not be placed until the Engineer has observed the formwork, reinforcement, and embedded items and debris has been removed.
  2. Whenever new concrete is to be placed against existing surfaces and at all construction joints, roughen and clean the surface to improve bond.
- B. Depositing Formed Concrete:
1. Except for beams, columns, or other deep structural monolithic members, place formed concrete in level layers no more than 24 inches deep. To prevent cold joints between layers, each successive layer shall be placed and consolidated before the preceding layer has taken its initial set. Place concrete in a continuous operation until the section is complete. The presence of cold joints shall constitute rejection of concrete.
  2. Formed concrete shall be directly placed in its final position, shall not be spaded, moved with vibrators, or permitted to fall over rods, spacers, reinforcement, or other embedded items. When depositing slabs and flatwork, runways and chutes shall be provided to discharge concrete close to final position to minimize spreading and segregation. Slabs shall be of one course monolithic construction.
  3. The concrete shall be handled from the mixer in carts, buggies or conveyors, and shall not be spouted or delivered by spout or trough from the hoists or dumped into carts with a free fall from the mixer of more than three feet. All concrete for walls shall be placed through frequently spaced openings in the inside forms or through "elephant trunks" equipped with suitable hopper heads. Tremies shall be of variable lengths so that the free fall of concrete does not exceed four feet, with a sufficient number placed in the forms to insure the concrete being kept level at all times.

### **3.4 CONSOLIDATING FORMED CONCRETE**



- A. Thoroughly compact all concrete with internal vibrators having a minimum frequency of 8000 vibrations per minute and sufficient amplitude and/or hand spading or rodding immediately after depositing, taking care to prevent any movement of the forms or reinforcement. Vibrate adjacent to waterstops and bulkheads to obtain a continuous bond and eliminate surface defects.
- B. Vertically insert and withdraw vibrators to consolidate each lift, partially penetrating the previous lift. Do not drag the vibrator nor allow it to come in contact with reinforcement or formwork. Do not attempt to laterally move concrete with the vibrators.

### 3.5 FINISHING SLABS AND FLATWORK

A. Finish Schedule:

- 1. Unless otherwise indicated, provide the following slab finishes:

<u>Description</u>	<u>Concrete Finish</u>
Exterior Slabs, Ramps, Walks, pavement, and stairs	Float & broom finish
Interior Floor slabs and Stairs	3 trowelings, 2 coats sealer

B. Concrete Tolerances:

- 1. Concrete shall be within 1/4-inch of a 10-foot straightedge in all directions, except where slabs are dished for drains. Deviations from the elevation indicated shall not exceed 1/4-inch.
- 2. Slabs sloped for drainage shall not have depressions which retain water.

C. Screeding:

- 1. Immediately after placement, screed concrete with straightedges or power strikeoffs. Do not use roller screeds or vibrating screeds.
- 2. Stakes for wet screeds shall be driven down flush with subgrade or pulled out as work progresses to avoid disturbing screeded concrete.

D. Float Finish:

- 1. Float concrete using magnesium or aluminum hand floats or power floats after the concrete has stiffened to a point where only a 1/4-inch indentation can be imparted by normal foot pressure.
- 2. Float finish shall result in a uniform, smooth, granular texture. After floating, check slab tolerances with 10-foot straightedge. Fill low spots with fresh concrete; do not sprinkle with dry cement.

E. Trowel Finish:

- 1. Where scheduled, or indicated, trowel with steel trowels after floating.
- 2. Initial troweling shall be done either by power or by hand with the trowel blade kept as flat as possible against concrete surface to prevent washboard or chatter effect.
- 3. Second troweling may be done by power if three trowelings are scheduled. If two trowelings are specified, second troweling shall be done by hand.
- 4. Third troweling shall be done by hand and shall continue until the concrete is consolidated to a uniform, smooth, dense surface free of trowel marks and irregularities.
- 5. Allow sufficient time between successive trowelings to allow the concrete to become harder. Each successive troweling shall be done with trowels that are progressively smaller and are tipped more to increase compaction of the concrete surface.

F. Broom Finish:

1. Broom at right angles to direction of traffic to give a non-skid finish. Use a fine, soft-bristled broom for pedestrian ramps and walks, and a coarse, hard-bristled broom for vehicular pavement.

G. Sealed Finish:

1. Where indicated, apply 3 coats of floor sealer in accordance with manufacturer's printed directions. Use the quantity recommended by the manufacturer. The surface shall be clean and dry before sealer is applied. Upon completion, leave concrete surfaces clean and without discoloration or traces of excess sealer.

**3.6 PROTECTION AND CURING**

A. General:

1. Comply with ACI 305 and 306 for protecting and curing concrete in hot and cold weather. Fresh concrete shall be protected from rain. Cure all concrete for a minimum period of 7 days with wet burlap, membrane curing compound, vapor barrier as specified herein, or continuous sprinkling over entire exposed surfaces as soon as the surfaces can be wetted without damage.

**3.7 DEFECTIVE CONCRETE**

- A. All concrete not formed as indicated on the Drawings within tolerances specified in ACI 347 shall be removed and replaced.
- B. Concrete requiring structural repairs shall either be replaced or, with prior written approval of the Engineer regarding methods and procedures, may be repaired with epoxy grout. Contractor to submit shop drawing for review.
- C. Concrete that has a defective surface shall be patched or replaced. If patching does not restore the quality and appearance of the surface, the defective concrete shall be replaced.
- D. At the direction of the Engineer, defective concrete shall be repaired by pressure grouting at no additional cost to the owner.

**3.8 FINISHING FORMED CONCRETE**

A. Patching:

1. After inspection by the Engineer, patch tie holes and defective areas. Where necessary, chip out defective areas to a minimum depth of 1-inch. Wet the area to be patched and the surrounding 6 inches to prevent absorption of water from the patching mortar and/or apply a brush coat of cement grout immediately prior to patching with mortar.
2. Thoroughly compact patching mortar into place and screed, leaving the patch slightly higher than the surrounding surface. For holes passing entirely through the wall use a plunger grout gun to force the mortar through the wall, starting at the back face undisturbed for a period of one to two hours to permit initial shrinkage before final flushing. The patch shall be finished to match the texture and appearance of the adjoining surface.
3. All patching shall be cured for three days and then inspected for shrinkage cracks. Cracking shall warrant complete removal and replacement of the patch.
4. Any existing concrete affected by proposed structure modifications shall be patched as described in paragraphs 1, 2, and 3 above.

B. Ordinary Finish:

1. The finish resulting directly from formwork shall be used for all surfaces which will be hidden from view by earth, submergence in water, or hidden by subsequent construction or coatings, except as otherwise indicated. Patch as specified.

C. Rubbed Finish:

1. Rubbed finish shall be provided for all interior and exterior cast-in-place concrete surfaces permanently exposed to view and all surfaces scheduled to be painted. Smooth finish shall be produced by using Grade A formwork and the following finish operations:
2. After patching as specified, grind joint marks and fins smooth using a fine carborundum or abrasive stone with clean water. Remove all oil stains by scrubbing the surface with stiff bristle brushes and a 5 to 10 percent muriatic acid solution. After the stains are removed, rinse the surface thoroughly with clean water. Rub immediately after forms are stripped.

**3.9 WATERPROOFING AND CORROSION PROTECTION**

A. General:

1. Leakage tests shall have been performed and any necessary remedial actions necessary to achieve acceptable leakage rates shall have been completed prior to commencing coating and waterproofing work.
2. Waterproofing and coating shall be performed by workmen who are regularly engaged and specialize in the application of the materials specified herein. The materials and methods shall be as specified herein, unless they are contrary to the manufacturer's directions. Deviation from the procedure specified will be permitted only upon the Engineer's review and providing the work is guaranteed by the Contractor as specified.

B. Surface Preparation:

1. All surfaces to be waterproofed and coated shall be free from mortar drippings, oil, earth, grease, or other surface coatings and shall be sound and free from holes, honeycomb, loose aggregate, or other surface conditions, which prevent satisfactory application of waterproofing or coating materials.

**3.10 WALL PIPES**

- A. All lines passing through concrete walls and slabs shall have wall pipes or sleeves with integral waterstops.

**3.11 PAYMENT**

- A. The cost of this work shall be considered incidental to the contract lump sum price for the project.

**END OF SECTION 03 3000**



**SECTION 04 0514**

**MASONRY MORTARING AND GROUTING**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Mortar and grout for masonry.

**1.2 REFERENCE STANDARDS**

- A. American Concrete Institute:
  - 1. ACI 530 - Building Code Requirements for Masonry Structures.
  - 2. ACI 530.1 - Specifications for Masonry Structures.
- B. ASTM International:
  - 1. ASTM C5 - Standard Specification for Quicklime for Structural Purposes.
  - 2. ASTM C91 - Standard Specification for Masonry Cement.
  - 3. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
  - 4. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
  - 5. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar.
  - 6. ASTM C150 - Standard Specification for Portland Cement.
  - 7. ASTM C199 - Standard Test Method for Pier Test for Refractory Mortars.
  - 8. ASTM C206 - Standard Specification for Finishing Hydrated Lime.
  - 9. ASTM C270 - Standard Specification for Mortar for Unit Masonry.
  - 10. ASTM C387/C387M - Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
  - 11. ASTM C404 - Standard Specification for Aggregates for Masonry Grout.
  - 12. ASTM C476 - Standard Specification for Grout for Masonry.
  - 13. ASTM C595 - Standard Specification for Blended Hydraulic Cements.
  - 14. ASTM C780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry.
  - 15. ASTM C1019 - Standard Test Method for Sampling and Testing Grout.
  - 16. ASTM C1142 - Standard Specification for Extended Life Mortar for Unit Masonry.
  - 17. ASTM C1314 - Standard Test Method for Compressive Strength of Masonry Prisms.
  - 18. ASTM C1329 - Standard Specification for Mortar Cement.
  - 19. ASTM C1357 - Standard Test Method for Evaluating Masonry Bond Strength.

**1.3 SUBMITTALS**

- A. Section 01 33 00 - Submittal Procedures: Submittal requirements.
- B. Design Data: Submit design mix when Property specification of ASTM C270 is to be used, required environmental conditions, and admixture limitations.
- C. Test Reports:
  - 1. Submit reports on mortar indicating conformance of mortar to property requirements of ASTM C270.

- 2. Submit reports on grout indicating conformance of grout to property requirements of ASTM C476 and test and evaluation reports conforming to ASTM C1019.
- D. Manufacturer's Installation Instructions: Submit premix mortar manufacturer's installation instructions.
- E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- F. Submit color sample.

#### **1.4 QUALITY ASSURANCE**

- A. Perform Work in accordance with ACI 530 and ACI 530.1.

#### **1.5 ENVIRONMENTAL REQUIREMENTS**

- A. Cold Weather Requirements: In accordance with ACI 530.1 when ambient temperature or temperature of masonry units is less than 40 degrees F.
- B. Hot Weather Requirements: In accordance with ACI 530.1 when ambient temperature is greater than 100 degrees F or ambient temperature is greater than 90 degrees F with wind velocity greater than 8 mph.

### **PART 2 - PRODUCTS**

#### **2.1 MORTAR AND MASONRY GROUT**

- A. Manufacturers:
  - 1. Lafarge North America Inc.
  - 2. QUIKRETE.
  - 3. Solomon Colors, Inc.
  - 4. Substitutions: Section 01 60 00 – Product Requirements.

#### **2.2 COMPONENTS**

- A. Portland Cement: ASTM C150, Type I, gray color.
- B. Mortar Aggregate: ASTM C144, standard masonry type.
- C. Hydrated Lime: ASTM C206, Type S.
- D. Grout Aggregate: ASTM C404, fine and coarse.
- E. Water: Clean and potable.
- F. Mortar Color: Mineral oxide pigment; Desert Bluff color to match existing.

#### **2.3 MIXES**

- A. Mortar mixes:
  - 1. Mortar For Structural Masonry: ASTM C270, Type M or S using Proportion specification.

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2. Mortar For Non-Structural Masonry: ASTM C270, Type S or N using Proportion specification.
  3. Mortar For Glass Unit Masonry: ASTM C270, Type N using Proportion specification.
- B. Mortar Mixing:
1. Thoroughly mix mortar ingredients in accordance with ASTM C270 in quantities needed for immediate use.
  2. Achieve uniformly damp sand immediately before mixing process.
  3. Add mortar color to achieve uniformity of mix and coloration.
  4. Re-temper only within two hours of mixing.
- C. Grout Mixes:
1. Grout for Non-Structural Masonry: 3,000 psi strength at 28 days; 7 to 8 inches slump; mixed in accordance with ASTM C476 Fine or coarse grout.
  2. Grout for Structural Masonry: 3,000 psi strength at 28 days; 7 to 8 inches slump; mixed in accordance with ASTM C476 Fine grout.
  3. Application:
    - a. Coarse Grout: For grouting spaces with minimum 4 inches dimension in every direction.
    - b. Fine Grout: For grouting other spaces.
- D. Grout Mixing:
1. Thoroughly mix grout ingredients in quantities needed for immediate use in accordance with ASTM C476.
  2. Add admixtures; mix uniformly.
  3. Do not use anti-freeze compounds to lower the freezing point of grout.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Request inspection of spaces to be grouted.

**3.2 FIELD QUALITY CONTROL**

- A. Establishing Mortar Mix: In accordance with ASTM C270.
- B. Testing of Grout Mix: In accordance with ASTM C1019 for compressive strength and in accordance with ASTM C143/C143M for slump.

**END OF SECTION 04 0514**





**SECTION 04 1000  
MORTAR AND GROUT**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified in this section.

**1.2 SUBMITTALS**

- A. Mortar and Grout
  - 1. Product data.
  - 2. Mortar mix designs. Must clearly state Portland cement, lime, proportional mix, of proper type.
  - 3. Grout mix design.
  - 4. Mortar test reports, ASTM C270 (Lab mixed) & ASTM C780 (Field mixed).
  - 5. Integral Water Repellent (IWR) Admixture, which is the same as the water repellent admixture products used in provided masonry products.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

- A. Mortar Mix: Prepackaged or silo mix, must clearly state Portland cement lime mortar mix. Masonry cement or mortar cement mortars are not acceptable.
- B. Masonry: Type N Portland cement lime mortar, complying with ASTM C270, Table 1 (Proportional design), with average compressive strength of 750 psi (800 psi max.).
- C. Grout Mix (for masonry & hollow metal frames): Comply with ASTM C476. Aggregate ASTM C404. Grout shall comply with proportion requirements of ASTM C476. 1 part Portland cement 1/10 part hydrated lime 3 parts sand 2 parts coarse aggregate (for coarse grout only, omit for fine grout). Fine or coarse grout mix as per ACI 530.1. Slump for masonry shall be 8-11 inches. Slump for hollow metal frames shall be 4 inches. Gypsum grout components are not allowed. Mortar is not an acceptable substitution for grout.
- D. Components for field mixed mortar and grout:
  - 1. Cement: Portland cement meeting the requirements of ASTM Specification C 150-81 Type I.
  - 2. Lime: Hydrated lime meeting standard specifications ASTM C 207 for hydrated lime, Type S.
  - 3. Sand: Well graded, clean, sharp mason sand meeting ASTM C 144-527.
  - 4. Water: Clean, fresh and free from salt, dirt and sewage and potable.
  - 5. Aggregate for Mortar: ASTM C 144.
  - 6. Aggregate for Grout: ASTM C 404.

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- E. Water Repellent Admixture: Provide water repellent admixture in mortar, which is the same as the water repellent admixture products used in provided masonry products to assure bonding of mortar to masonry products. Use at masonry which has integral water repellent.
- F. Provide mortar, products and accessories compatible with specified masonry products for a complete and proper installation and to assure bonding of mortar to masonry products.
- G. Other Admixtures: The use of calcium chloride or other agents for lowering freezing temperature, or for accelerating, or any other admixtures not listed herein, are not allowed.

**PART 3 - EXECUTION**

**3.1 MIXING**

- A. Mix mortar in such quantities that it will be used within a reasonable time. Re-tempering of mortar is not allowed.

**3.2 TESTING MORTAR**

- A. The Owner will engage one or more Materials & Geotech Testing agencies to conduct tests for mortar. Refer to Section 01 41 00 - Materials & Geotech Testing for additional requirements.

**END OF SECTION 04 1000**

**SECTION 04 2000**

**UNIT MASONRY**

**PART 1 - GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Brick and concrete masonry units; pre-faced brick and concrete masonry units; reinforcement, anchorage, and accessories.

**1.2 REFERENCE STANDARDS**

A. American Concrete Institute:

1. ACI 530 - Building Code Requirements for Masonry Structures.
2. ACI 530.1 - Specifications for Masonry Structures.

B. ASTM International:

1. ASTM A82/A82M - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
3. ASTM A580/A580M - Standard Specification for Stainless Steel Wire.
4. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
5. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
6. ASTM A951/A951M - Standard Specification for Steel Wire for Masonry Joint Reinforcement.
7. ASTM B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
8. ASTM C55 - Standard Specification for Concrete Brick.
9. ASTM C67 - Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile.
10. ASTM C73 - Standard Specification for Calcium Silicate Face Brick (Sand-Lime Brick).
11. ASTM C90 - Standard Specification for Loadbearing Concrete Masonry Units.

12. ASTM C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
13. ASTM C216 - Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale).
14. ASTM C549 - Standard Specification for Perlite Loose Fill Insulation
15. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
16. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
17. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
18. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

### **1.3 PERFORMANCE REQUIREMENTS**

- A. Clay Masonry Compressive Strength (f'm): 3,000 psi; determined by unit strength method.
- B. Concrete Masonry Compressive Strength (f'm): 1,500 psi; determined by unit strength method.

### **1.4 SUBMITTALS**

- A. Product Data:
  1. Submit data for pre-faced masonry units, fabricated wire reinforcement, wall ties, anchors, and other accessories.
  2. Indicate initial rate of absorption for clay and shale brick.
- B. Samples: Submit four samples of face brick, units to illustrate color, texture, and extremes of color range.
- C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

### **1.5 QUALITY ASSURANCE**

- A. Perform Work in accordance with ACI 530 Building Code Requirements for Masonry Structures and ACI 530.1 Specification for Masonry Structures.
- B. Surface Burning Characteristics:
  1. Foam Insulation: Maximum 75/450 flame spread/smoke developed index when tested in accordance with ASTM E84.
- C. Apply label from agency approved by authority having jurisdiction to identify each foam plastic insulation insert.

- D. Perform Work in accordance with of International Building Code.

## **1.6 QUALIFICATIONS**

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

## **1.7 PRE-INSTALLATION MEETINGS**

- A. Convene minimum one week prior to commencing work of this section.

## **1.8 DELIVERY, STORAGE, AND HANDLING**

- A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.
- B. Accept units on site. Inspect for damage.

## **1.9 ENVIRONMENTAL REQUIREMENTS**

- A. Cold Weather Requirements: In accordance with ACI 530.1 when ambient temperature or temperature of masonry units is less than 40 degrees F.
- B. Hot Weather Requirements: In accordance with ACI 530.1 when ambient temperature is greater than 100 degrees F or ambient temperature is greater than 90 degrees F with wind velocity greater than 8 mph.

## **1.10 COORDINATION**

- A. Section 01 30 00 - Administrative Requirements: Coordination and project conditions.
- B. Coordinate masonry work with installation of window and door anchors.

# **PART 2 - PRODUCTS**

## **2.1 COMPONENTS**

- A. Facing Brick: ASTM C216, Type FBX, Grade SW; color, texture, and size to match existing construction. Provide samples for review.
- B. Brick Size and Shape: Nominal size of 4 x 2-2/3 x 8 inches, unless noted otherwise in contract drawings (field verify size of existing units)
- C. Hollow Load Bearing Concrete Masonry Units (CMU): ASTM C90; medium weight.
- D. Solid Load-Bearing Concrete Masonry Units (CMU): ASTM C90; medium weight.
- E. Concrete Masonry Unit Size and Shape: Size as indicated on the Drawings. Furnish special units for 90 degree corners, bond beams, lintels, coved base, and bullnosed corners.

## **2.2 ACCESSORIES**

- A. Single Wythe Joint Reinforcement: ASTM A951/A951M; ladder type; steel; 3/16 inch diameter side rods with 0.148 inch diameter cross ties; hot dip galvanized.

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- B. Multiple Wythe Joint Reinforcement: ASTM A951/A951M; ladder type; steel; with moisture drip; 3/16 inch diameter side rods with 0.148 inch diameter cross ties; hot dip galvanized.
- C. Reinforcing Steel: ASTM A615/A615M, 60 ksi yield grade, deformed billet bars, uncoated finish.
- D. Wall Ties: ASTM A82/A82M; steel wire 3/16 inch diameter side rods x 9 gauge cross rods; adjustable eye and pintle type; ASTM A153/A153M hot dip galvanized.
- E. Dovetail Anchors: Flexible dovetail brick tie, 3/16 inch diameter; ASTM A153/A153M hot dip galvanized.
- F. Anchor Rods: ASTM A307; Grade C; J-shaped or L-shaped; complete with washers and heavy hex nuts; sized for minimum 15 inch embedment; hot-dipped galvanized per ASTM A153/A153M.
- G. For securing brick veneer to concrete substrate use heavyweight Hohmann & Barnard Type 345-BT Flexible Ties, hot dip galvanized with galvanized hardware for securing to concrete.
- H. Mortar and Grout: As specified in Section 04 05 14 - Masonry Mortaring and Grouting.
- I. Galvanized Steel: ASTM A653/A653M, G90 finish, 24 gage core steel.
- J. Self-Stick SBS Type Flashing: Composite sheet 40 mils (1.0 mm) thick; 38 mils (0.96 mm) thick self-adhesive rubberized asphalt bonded to 2 mils (0.04 mm) thick high density polyethylene film.
- K. Lap Sealant: Nonsag Polyurethane type as specified in Section 07 92 00 – Joint Sealants.
- L. Preformed Control Joints: Neoprene material. Furnish with corner and tee accessories, heat fused joints.
- M. Joint Filler: Closed cell rubber; oversized 50 percent to joint width; self-expanding.
- N. Manufacturers: Cavity Drain Material: Open high density polyethylene (HDPE) woven mesh 10 inches high by 1 inches thick, as required to fill cavity space, and shaped to ensure moisture drainage to cavity weeps.
  - 1. Keene Building Products.
  - 2. Mortar Net USA, Ltd.
  - 3. Substitutions: Section 01 60 00 - Product Requirements.
- O. Building Paper: ASTM D226; Type II, No. 30 unperforated asphalt felt.
- P. Nailing Strips: Softwood, preservative treated for moisture resistance, dovetail shape, sized to masonry joints.
- Q. Weeps: Preformed plastic tubes, hollow. Open head joints.

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- R. Cavity Vents: Molded polyvinyl chloride grilles; insect resistant.
- S. Cleaning Solution: Non-acidic, not harmful to masonry work or adjacent materials.
- T. Steel Lintels: size as indicated on Drawings, hot-dip galvanized.
- U. Fire Proofing: hollow spaces in CMU walls may be completely filled with perlite or vermiculite to increase firing rating, as required.

**2.3 SOURCE QUALITY CONTROL**

- A. Section 01 40 00 - Quality Requirements: Testing, inspection and analysis requirements.
- B. Test brick efflorescence in accordance with ASTM C67. Brick rated greater than "slightly effloresced" is not acceptable.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Section 01 30 00 - Administrative Requirements: coordination and project conditions.
- B. Verify field conditions are acceptable and are ready to receive work.
- C. Verify items provided by other sections of work are properly sized and located.
- D. Verify built-in items are in proper location, and ready for roughing into masonry work.

**3.2 PREPARATION**

- A. Direct and coordinate placement of metal anchors supplied to other sections.
- B. Furnish temporary bracing during installation of masonry work. Maintain in place until building structure provides permanent support.
- C. Wet clay and shale brick before laying when initial rate of absorption is greater than 30 grams when tested in accordance with ASTM C67.

**3.3 INSTALLATION**

- A. Establish lines, levels, and coursing indicated. Protect from displacement.
- B. Maintain masonry courses to uniform dimension. Form bed and head joints of uniform thickness.
- C. Coursing of Concrete Masonry Units:
  - 1. Bond: Running.
  - 2. Coursing: One unit and one mortar joint to equal 8 inches.
  - 3. Mortar Joints: Concave.
- D. Coursing of Brick Units:

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1. Bond: Running.
2. Coursing: Three units and three mortar joints to equal 8 inches.
3. Mortar Joints: Concave.

E. Placing And Bonding:

1. Lay masonry units in full bed of mortar, with full head joints.
2. Buttering corners of joints or excessive furrowing of mortar joints are not permitted.
3. Remove excess mortar as work progresses.
4. Interlock intersections and external corners.
5. Do not shift or tap masonry units after mortar has achieved initial set. Where adjustment is required, remove mortar and replace.
6. Perform job site cutting of masonry units with proper tools to assure straight, clean, unchipped edges. Prevent broken masonry unit corners or edges.
7. Cut mortar joints flush where cavity insulation vapor retarder adhesive is applied.
8. Isolate top of masonry from horizontal structural framing members and slabs or decks with compressible joint filler.

F. Weeps and Vents: Furnish weeps and vents in outer wythe at 24 inches on center horizontally above through-wall flashing, above shelf angles and lintels, and at bottom of walls.

G. Cavity Wall: Do not permit mortar to drop or accumulate into cavity air space or to plug weeps. Build inner wythe ahead of outer wythe to receive cavity insulation and air/vapor retarder adhesive.

1. Install cavity drain material continuously at bottom of each cavity above through wall flashing.

H. Joint Reinforcement And Anchorages - Cavity Wall Masonry:

1. Install horizontal joint reinforcement 16 inches oc.
2. Place masonry joint reinforcement in first and second horizontal joints above and below openings. Extend minimum 24 inches each side of opening except at control joints.
3. Place joint reinforcement continuous in first and second joint below top of walls.
4. Lap joint reinforcement ends minimum 6 inches. Extend minimum 24 inches each side of openings except at control joints.
5. Embed anchors in concrete. Embed anchorages in every second block joint.



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6. Reinforce joint corners and intersections with strap anchors 16 inches oc.

I. Reinforcement And Anchorages - Multiple Wythe Unit Masonry:

1. Install horizontal joint reinforcement 16 inches oc.
2. Place masonry joint reinforcement in first and second horizontal joints above and below openings. Extend minimum 24 inches each side of opening except at control joints.
3. Place joint reinforcement continuous in first and second joint below top of walls.
4. Lap joint reinforcement ends minimum 6 inches. Extend minimum 24 inches each side of openings except at control joints.
5. Support and secure reinforcing bars from displacement. Maintain position within 1/2 inch of dimensioned position.
6. Embed anchors embedded in concrete. Embed anchorages in every second block joint.
7. Reinforce joint corners and intersections with strap anchors 16 inches oc.
8. Cut joint truss reinforcement at horizontal structural members and tack weld to the structural steel on both sides.

J. Masonry Flashings:

1. Extend flashings horizontally through outer wythe at foundation walls, above ledge or shelf angles and lintels, under parapet caps, at bottom of walls, and turn down on outside face to form drip.
2. Turn flashing up minimum 8 inches and bed into mortar joint of masonry backing.
3. Lap end joints minimum 6 inches and seal watertight.
4. Turn flashing, fold, and seal at corners, bends, and interruptions.

K. Lintels:

1. Install steel lintels over openings as indicated on Contract Drawings.
2. Do not splice reinforcing bars.
3. Support and secure reinforcing bars from displacement.
4. Place and consolidate grout fill without displacing reinforcing.
5. Maintain minimum bearing on each side of opening as shown on drawings.

L. Grouted Components:

1. Reinforce bond beam with 2, No. 5 bars, 1 inch from bottom web unless noted otherwise in Contract Drawings.

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2. Support and secure reinforcing bars from displacement.
3. Place and consolidate grout fill without displacing reinforcing.
4. At bearing locations, fill masonry cores with grout for minimum 12 inches both sides of opening.

M. Reinforced Masonry:

1. Lay masonry units with core cells vertically aligned and cavities between wythes clear of mortar and unobstructed.
2. Place reinforcement bars as indicated on Drawings.
3. Splice reinforcement in accordance with Section 03 20 00 – Concrete Reinforcing.
4. Support and secure reinforcement from displacement.
5. Place and consolidate grout fill without displacing reinforcing.
6. Place grout in accordance with ACI 530.1 Specification for Masonry Structures.

N. Control Joints:

1. Install control joints at the locations indicated on Contract Drawings.
2. Do not continue horizontal joint reinforcement through control joints.
3. Install preformed control joint device in continuous lengths. Seal butt and corner joints.
4. Size control joint in accordance with Section 07 92 00 - Joint Sealants for sealant performance.
5. Form expansion joint by omitting mortar and cutting unit to form open space.

O. Built-In Work:

1. As work progresses, install built-in metal door and glazed frames, fabricated metal frames, window frames, anchor bolts, plates, and other items to be built-in the work and furnished by other sections.
2. Install built-in items plumb and level.
3. Bed anchors of metal door and glazed frames in adjacent mortar joints. Fill frame voids solid with grout or mortar.
4. Do not build in materials subject to deterioration.

P. Cutting And Fitting:

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1. Cut and fit for chases, pipes, conduit, sleeves, grounds, and other items. Coordinate with other sections of work to provide correct size, shape, and location.
  2. Obtain Engineer's approval prior to cutting or fitting masonry work not indicated or where appearance or strength of masonry work may be impaired.
- Q. Install Work in accordance with State of Illinois and Kendall County standards.

**3.4 ERECTION TOLERANCES**

- A. Section 01 40 00 - Quality Control: Tolerances.
- B. Maximum Variation from Alignment of Columns:  $\frac{1}{4}$  inch.
- C. Maximum Variation from Unit to Adjacent Unit:  $\frac{1}{16}$  inch.
- D. Maximum Variation from Plane of Wall:  $\frac{1}{4}$  inch in 10 feet and  $\frac{1}{2}$  inch in 20 feet or more.
- E. Maximum Variation from Plumb:  $\frac{1}{4}$  inch per story non-cumulative;  $\frac{1}{2}$  inch in two stories or more.
- F. Maximum Variation from Level Coursing:  $\frac{1}{8}$  inch in 3 feet and  $\frac{1}{4}$  inch in 10 feet;  $\frac{1}{2}$  inch in 30 feet.
- G. Maximum Variation of Joint Thickness:  $\frac{1}{8}$  inch in 3 feet.
- H. Maximum Variation from Cross Sectional Thickness of Walls:  $\frac{1}{4}$  inch.
- I. Maximum Variation for Steel Reinforcement:
  1. Install reinforcement within the tolerances specified in ACI 530.1 for foundation walls.
  2. Plus or minus  $\frac{1}{2}$  inch when distance from centerline of steel to opposite face of masonry is 8 inches or less.
  3. Plus or minus 1 inch when distance is between 8 and 24 inches.
  4. Plus or minus  $1\frac{1}{4}$  inch when distance is greater than 24 inches.
  5. Plus or minus 2 inches from location along face of wall.

**3.5 FIELD QUALITY CONTROL**

- A. Brick Units: Test each type in accordance with ASTM C67, 5 random units for each 50,000 units installed.
- B. Concrete Masonry Units: Test each type in accordance with ASTM C140.

**3.6 CLEANING**

- A. Remove excess mortar and mortar smears as work progresses.

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- B. Replace defective mortar. Match adjacent work.
- C. Clean soiled surfaces with cleaning solution.
- D. Use non-metallic tools in cleaning operations.

**3.7 PROTECTION OF FINISHED WORK**

- A. Protect exposed external corners subject to damage.
- B. Protect base of walls from mud and mortar splatter.
- C. Protect masonry and other items built into masonry walls from mortar droppings and staining caused by mortar.
- D. Protect tops of masonry work with waterproof coverings secured in place without damaging masonry. Provide coverings where masonry is exposed to weather when work is not in progress.

**END OF SECTION 04 2000**

**SECTION 04 2000**  
**UNIT MASONRY**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified in this section.

**1.2 SUBMITTALS**

- A. Product data for each of the following.
  - 1. CMU
  - 2. Face Brick
  - 3. Masonry Cleaning Products
  - 4. Built-in members, flashings, reinforcing, and accessories
- B. Samples for each of the following.
  - 1. Facebrick to match existing
  - 2. Submit samples of face brick for review and approval as a match. If face brick sample is not acceptable, submit additional samples for review and approval as a match until acceptance.

**1.3 QUALITY ASSURANCE**

- A. Pre-Installation Masonry Meeting: Meeting with Architect and Contractor; Contractor shall review procedures to provide quality installation of the work, including: mockup sketch and installation, material selections, accessories, detailing, protection of masonry materials and walls from weather, control joints, cold weather construction and protection, special masonry materials or units or finishes, special or unusual details or conditions, and other requirements of this section.
- B. Materials:
  - 1. Do not change source or brands of masonry materials during the Work.
  - 2. Obtain masonry units from one manufacturer, cured (if applicable) by one process and of uniform texture and color, for each type required for each continuous area and visually related areas.
  - 3. Fire-Resistive ratings: Provide materials and construction identical to those of assemblies with fire-resistive ratings determined per ASTM E 119 by a testing and inspection agency, by equivalent concrete masonry thickness, or other means, as acceptable to authorities having jurisdiction.
  - 4. Regulatory Requirements: Comply with the applicable requirements of governing authorities and codes.

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5. Unit Masonry Standard: Comply with TMS602/ACI530.1/ASCE6 current edition "Specifications for Masonry Structures," except as otherwise specified.
6. Coordination: Review installation procedures and coordinate with other Work that must be integrated with masonry.

**1.4 FIELD-CONSTRUCTED MOCK-UP**

- A. Prior to installation of masonry, erect mock-up to comply with the following requirements, using preliminary masonry unit selections:
  1. Submit a shop drawing sketch of the proposed mock-up panel, prior to mock-up panel construction, showing front and rear elevations.
  2. Build Mock-Up approximately 8 feet long by 6 feet high, with a 1 foot 4 inch corner return, full wall thickness, including face and backup wythes as well as masonry accessories. Mockup shall be constructed upon a stable concrete foundation.
  3. Include each and every masonry type used on the building, both interior and exterior.
  4. Install full range of color, texture, etc. of masonry units in the mock up.
  5. Wall construction shall include typical wall vocabulary including flashing and drip edge, drainage mesh, insulation, weep holes, reinforcing, brick and CMU control joints, etc. Leave base of wall flashing partially exposed for viewing flashing installation.
  6. Include masonry details such as: special banding, bonding, mortar joint profiles, etc. Foreshorten typical wall construction as required to fully include top of wall cornice, wall banding, etc.
  7. Window opening: 16" x 16" opening including jamb, sill, head with lintel, jamb closure wood blocking, weep holes, flashing, and drip edge. Leave flashed lintel partially exposed for viewing flashing and end dam installation. Leave window sill flashing partially exposed for viewing flashing, flashing support, and end dam installation.
  8. Protect the mock-up wall cavity from the elements, with a typical top of masonry wall with wood blocking, flashing, and cap installation at the top of the mock-up wall. Leave one end of the top of wall partially exposed for viewing flashing, flashing support, and blocking installation.
  9. Construct the mock-up 21 days prior to the date selections are to be finalized. Approved mockup does not constitute approval to deviate from specifications.
  10. Retain and maintain mock-up during construction in undisturbed condition until directed to remove the mock-up. When directed, demolish and remove mock-up from project site.

**1.5 MASONRY WARRANTY**

- A. The Contractor accepts the responsibility of providing proper workmanship, including completely filling head and bed joints with mortar, proper installing of flashings, and the assumption that leaks through the walls, cracks in the mortar, and improper bonding to

masonry units will be due to the Contractor's improper workmanship. Contractor further warrants that the walls will not leak, cracks will not occur in the mortar, and the mortar will be properly bonded to masonry units, and flashing will be properly installed. Contractor agrees to cut out mortar joints to 3/4" depth in areas with either leaks, cracks, or poorly bonding, to point them with mortar, and to replace improperly installed flashings, until such conditions have been stopped. This warranty covers a period of 2 years from the date of Substantial Completion.

## **1.6 PROJECT CONDITIONS**

- A. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602, and as indicated herein.
- B. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
- C. Masonry Protections:
  - 1. During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress. Extend cover a minimum of 24 inches down both sides and hold cover securely in place.
    - a. Where one wythe of multi wythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches down face next to unconstructed wythe and hold cover in place.
  - 2. Do not apply uniform floor or roof loads or concentrated loads for at least 7 days after constructing masonry walls or columns which support these loads.
  - 3. Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Remove immediately any grout, mortar, and soil that comes in contact with such masonry.
  - 4. Protect base of walls from rain-splashed mud and mortar splatter.
  - 5. Protect sills, ledges, and projections from grout and mortar droppings.
  - 6. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes from grout and mortar droppings.

## **PART 2 - PRODUCTS**

### **2.1 MASONRY UNITS**

- A. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work; if units are installed exposed they will be subject to rejection and replacement.
- B. Fire-Resistance Ratings: Where indicated, provide units that comply with requirements for fire-resistance ratings indicated as determined by testing according to ASTM E 119, by equivalent masonry thickness, or by other means, as acceptable to authorities having jurisdiction, and as specified within.

## **2.2 CONCRETE MASONRY**

- A. Concrete block: Standard medium weight concrete block, ASTM C-90, Grade N, Type I, for concrete masonry units.
1. Interior partitions and exterior back-up medium weight except as otherwise called for on drawings of Haydite, Arcalite, or Solite Plus Limestone. Metallic admixtures not allowed.
  2. Maximum weight of thoroughly cured 8" x 16" medium weight block: 34 lbs. Density, 105-125 lbs. per cu. ft. Blocks shall be of true height so courses and joints line up and be uniform. Interior exposed block shall have a fine to dense uniform surface texture free from superficial defects, to be supplied from one manufacturer.
  3. Minimum net area compressive strength of concrete masonry units shall be 3,000 psi or net area compressive strength of masonry, f'm shall be 1775 by the prism strength test method.
  4. The block, other than those which are autoclave cured, shall be a minimum of 90 days old. Furnish a certification that blocks furnished for this project are a minimum of 90 days when delivered.
  5. 5. Fire Rating:
    - a. 4" and 6" concrete block: Certified classification C-1 (1-hour rating).
    - b. 8" and 12" concrete block: Certified classification C-2 (2-hour rating).
  6. Earlier delivery may be approved when the manufacturer utilizes special curing, or drying processes, or both, which insure the delivery of cured units with a moisture content of less than 30% of total absorption.
  7. Special shapes: At interior block, exposed outside vertical corners shall be bull nosed except door and window jambs, unless shown otherwise. Provide bull nosed units for window sills, unless shown otherwise. Bull nose units shall be manufactured, not field fabricated. Lintel & bond beam block with "U" shape for use at block lintels and bond beams as called for by the Drawings. Special "control joint" slotted sash units to be provided at masonry control joints. Use solid concrete brick of load bearing grade, where required to adjust steel bearing elevation.

## **2.3 FACE BRICK**

- A. General: Provide shapes indicated and as follows:
1. For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
  2. Provide special shapes for applications where shapes produced by sawing would result in sawed surfaces being exposed to view.
  3. Provide special shapes as detailed or required, including corner brick (other than 90 degree corners) angle units, solid units, etc. Use solid brick at recessed or projected courses, and at corbelling.



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4. Initial Rate of Absorption (IRA): Provide test data of Initial Rate of Absorption to verify less than 30g / 30sq. in. per minute when tested per ASTM C 67.
  5. Efflorescence: Provide brick that has been tested according to ASTM C 67 and is rated "not effloresced."
- B. Face brick to be the same color, manufactured by the same manufacturer, and produced on the same run to assure color match. Face brick to be in sizes and textures as selected.
1. Face brick shall be furnished where indicated or required. Face brick shall match existing adjacent face brick size, color, texture, etc.
  2. Submit samples of face brick for review and approval as a match for exiting masonry for each school. If face brick sample is not acceptable, submit additional samples for review and approval as a match until acceptance.
- C. Allowance: Provide material cost allowance noted above for each masonry type, F.O.B. jobsite, unloaded in a location as directed by Contractor.
1. Submit substantiating paperwork for review prior to final approval of the brick selections.
  2. Final Itemized Cost Accounting will be reviewed for adjustment of masonry allowance.

## 2.4 REINFORCEMENT

- A. Uncoated Steel Reinforcing Bars: Billet steel deformed bars complying with ASTM A 615/A 615M, Grade 60.
- B. Masonry Joint Reinforcement, General: ASTM A 951/A 951M.
1. Interior Walls: Class 1 Mill galvanized, carbon steel (ASTM A641).
  2. Exterior Walls: Class B-2 Hot-dip galvanized, carbon steel (ASTM A153).
  3. Wire Size for Side Rods: 9 gauge.
  4. Wire Size for Veneer Ties: 9 gauge.
  5. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches o.c.
- C. Horizontal Joint Reinforcement: Welded-wire units prefabricated with prefabricated corner and tee units. Width of reinforcing shall be not less than two inches (2") less than total width of wall. Provide prefabricated corners and/or tees at intersecting masonry walls.
1. For multi-wythe masonry, provide type as follows: Ladder Design with cross rods spaced not more than 16 inches o.c. and number of side rods as follows: Number of side rods for multi-wythe concrete masonry: One side rod for each face shell of hollow masonry units more than 4 inches in nominal width plus one side rod for each wythe of masonry 4 inches or less in nominal width. Provide drip at cross rod between wythes.
  2. For single-wythe masonry, provide type as follows with single pair of side rods: Truss Design with continuous diagonal cross rods spaced not more than 16" o.c.
  3. For multi-wythe masonry, where construction of the concrete block precedes the

installation of the exterior veneer, or alignment or horizontal masonry joints do not align between wythes, provide: Ladder Design with cross rods spaced not more than 16 inches o.c., with side rods & accessories as follows: Two side rods at the interior concrete block masonry. One rod at 4" thick exterior masonry wythe, or two ladder type rods at exterior 6" or thicker masonry veneer. 3/16" diameter wire U anchor fabricated to secure a similar wire bent tie. Provide an interlock system (Holmann & Barnard, Inc. "Seismiclip" or comparable), such that the exterior masonry wire reinforcing is tied back to the interior reinforcing.

4. Manufacturers:
  - a. Holmann & Barnard, Inc.
  - b. Heckmann Building Products, Inc.

## **2.5 TIES AND ANCHORS**

- A. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated.
  1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M; with ASTM A 153/A 153M, Class B-2 coating.
  2. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.
  3. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- B. Wire Ties, General: Unless otherwise indicated, size wire ties to extend at least halfway through veneer but with at least 5/8" cover on outside face. Outer ends of wires are bent 90 degrees and extend 2 inches parallel to face of veneer.

## **2.6 EMBEDDED FLASHING MATERIALS**

- A. Flexible Flashing: Use the following unless otherwise indicated, for damp course and through wall flashing:
  1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 0.040" (40 mil.).
    - a. Products: Subject to compliance with requirements, provide one of the following available products:
      1. Grace Construction Products, W. R. Grace & Co. - Conn.; Perm-A-Barrier Wall Flashing.
      2. IPCO; Self Adhesive Rubberized Asphalt Flashing.
      3. W.R. Meadows, Inc., Air-Shield Thru-Wall Flashing
    - b. Associated Flashing Accessories:
      1. Mastic: Mastic compatible with flashing materials, supplied by flashing manufacturer.
      2. Termination bar: Stainless steel, type 304, Size: 1/8" thick x 1"

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- wide with holes pre-drilled 6" or 8" o.c.
3. Primer: Primer compatible with flashing materials, supplied by flashing manufacturer.
  4. Drip Edge Flashing: Shall be stainless steel, type 304, 26 gauge, 1 5/8" min. depth with 2B finish, shall be installed in accordance with manufacturer's recommendation. Provide preformed corners where available from manufacturer. Approved manufacturers subject to requirements as listed:
    - a. Hohmann & Barnard, Inc.
    - b. Sandell Manufacturing.
    - c. IPCO.
  5. Flashing Support within wall cavity: IPCO stainless steel (type 304 minimum 28ga) cavity bridge, type F, L, Z, as applicable.
  6. Preformed Door Jamb End Dam: IPCO stainless steel (type 304 minimum 28ga) with diagonal end dam. Use at unsupported end dam conditions.

**2.7 MISCELLANEOUS MASONRY ACCESSORIES**

- A. Control joint shear key to be premolded joint filler for use with CMU sash block.
  1. Hohmann & Barnard; RS Series
  2. Heckman Building Products, Inc.; comparable to (1)
  3. Dur-O-Wall; DA 2000 Series
- B. Expansion Joint Filler, Non-metallic (for use at exterior wythe of exterior masonry walls at Expansion Joint): Pre-molded filler strips complying with ASTM D 1056, Type 2, (closed cell), Class A (cellular rubber and rubber-like materials with resistance to petroleum base oils), Grade 1 (compression-deflection range of 2 to 5 psi), compressible up to 35 percent, of width indicated, formulated from the following material:
  1. Neoprene.
  2. Urethane.
- C. Bond-Breaker Strips: Asphalt-saturated, organic roofing felt complying with ASTM D 226, Type I (No. 15 asphalt felt).
- D. Weep Hole Rope: Sash cord, cotton, 3/8" diameter, 12" minimum length.
- E. Cavity Drainage Mesh: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity; 1" thick by approximately 10 inches high, polyethylene, polyester, or nylon mesh, 90% open weave, with a top surface in a trapezoidal (dovetail) configuration designed to allow moisture to flow downward in the cavity to masonry flashing and weeps. Drainage system shall be continuous at base of wall and above flashed installations where the cavity extends at least 24" above. Match clear cavity width to drainage mesh thickness. Clear cavity width should be no more than 1/4" wider than the drainage mesh thickness. Make adjustments to the clear cavity width, by

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installing an additional 12" high piece of rigid cavity wall insulation, thickness as required, in back of the drainage mesh, such that there remains no more than 1/4" of clear cavity space. Approved manufacturers, subject to compliance with these requirements:

1. Mortar Net USA, Ltd.; Mortar Net.
2. Hohmann & Barnard, Inc.; Mortar Trap.
3. CavClear; Mortar Drop Stop.

## **2.8 MASONRY CLEANERS**

- A. Proprietary Masonry Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Diedrich Technologies, Inc.
    - b. ProSoCo, Inc.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION, GENERAL**

- A. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.
- B. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures.
- C. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. per minute when tested per ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.
- D. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond with vertical joint in each course centered on units in courses above and below.
1. Match existing bond unless noted otherwise

### **3.2 TOLERANCES**

- A. Dimensions and Locations of Elements:
1. For dimensions in cross section or elevation do not vary by more than plus 1/2" or minus 1/4".
  2. For location of elements in plan do not vary from that indicated by more than plus or minus 1/2".
  3. For location of elements in elevation do not vary from that indicated by more than

plus or minus 1/4" in a story height or 1/2" total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls do not vary from level by more than 1/4" in 10 feet, or 1/2" maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8" in 10 feet, 1/4" in 20 feet, or 1/2" maximum.
3. For vertical lines and surfaces do not vary from plumb by more than 1/4" in 10 feet, 3/8" in 20 feet, or 1/2" maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8" in 10 feet, 1/4" in 20 feet, or 1/2" maximum.
5. For lines and surfaces do not vary from straight by more than 1/4" in 10 feet, 3/8" in 20 feet, or 1/2" maximum.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8", with a maximum thickness limited to 1/2".
2. For head and collar joints, do not vary from thickness indicated by more than plus 3/8" or minus 1/4".
3. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8".

### 3.3 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond pattern for exposed masonry as indicated in paragraph 3.01. Do not use units with less than nominal 4" horizontal face dimensions at corners or jambs.
  1. Lay concealed masonry with all units in a wythe bonded by lapping not less than 2 inches. Bond and interlock each course of each wythe at corners.
- C. Discard units with cracked faces, chipped edges, or corners or other defects that affect appearance or performance.
- D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
  1. Install steel lintels, bearing plates, etc. plumb and level.
- E. Fill cores in hollow CMU's with grout 24 inches each way under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- F. Chases. Ascertain from each trade subcontractor where chases or openings for pipes, wires, ducts, etc., are to go and do not wait for such information to be given. Construct such chases as shown or required.

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- G. Build in anchors, bolts, flashings, wall plugs, nailing strips, frames, etc., as may be required. Place these materials according to directions of those manufacturers who furnish them, except as exceeded herein.
- H. Provide openings as shown or required for windows, doors, as well as mechanical, electrical, plumbing, and other items."
- I. Grout hollow metal frames in masonry or concrete partitions, filling with concrete grout vertical frame members, except for the bottom 8". Do not grout hollow metal frames at gypsum walls. Grout shall comply with ASTM C 476, mixed to provide a 4" maximum slump, and hand troweled into place. Do not use grout mixed to a thin/pumpable consistency, or with an accelerant, or with antifreeze, or with a chloride, or a gypsum grout, any of which may cause premature rusting of frames.
- J. Rake and caulk exposed sill and coping head joints; rake joints 1/2" deep, install backer rod and sealant.

### **3.4 CONTROL JOINTS**

- A. Exterior wall control joints shall be provided where indicated on the drawings.
- B. Interior wall control joints shall be provided at the following applications:
  - 1. At non-vertically reinforced wall runs where the length (L) to height (H) ratio (L/H) exceeds 2. Where practicable, place required joint near corners, near intersecting walls and at edges of large openings.
  - 2. At changes in wall height or thickness including at pilasters.
  - 3. At locations where structural columns are fully encased within masonry.

### **3.5 MORTAR BEDDING AND JOINTING**

- A. Lay hollow brick and CMU's as follows:
  - 1. With face shells fully bedded in mortar and with head joints of depth equal to bed joints.
  - 2. With webs fully bedded in mortar in courses of piers, columns, and pilasters.
  - 3. With webs fully bedded in mortar in grouted masonry, including starting course on footings.
  - 4. With entire units, including areas under cells, fully bedded in mortar at starting course on footings where cells are not grouted.
- B. Lay solid masonry units with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.
- C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated. Joints 16" above ceilings, and that will not be exposed shall be struck flush.

### **3.6 CAVITY WALLS**

- A. Bond wythes of cavity walls together using the following methods:

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1. Individual Metal Ties: Provide ties as shown installed in horizontal joints, but not less than one metal tie for 2.67 sq. ft. of wall area spaced not to exceed 24 inches o.c. horizontally and 16 inches o.c. vertically. Stagger ties in alternate courses. Provide additional ties within 12 inches of openings and space not more than 36 inches apart around perimeter of openings. At intersecting and abutting walls, provide ties at no more than 16 inches o.c. vertically.
2. Masonry Joint Reinforcement: Installed in horizontal mortar joints.
  - a. Where bed joints of both wythes align, use ladder-type reinforcement extending across both wythes or adjustable two-piece tab-type reinforcement if veneer is installed later.
  - b. Where bed joints of wythes do not align, use adjustable (two-piece) type reinforcement with continuous horizontal wire in facing wythe attached to ties.
  - c. Where one wythe is of clay masonry and the other of concrete masonry, use adjustable (two-piece) type reinforcement with continuous horizontal wire in facing wythe attached to ties to allow for differential movement regardless of whether bed joints align.
- B. Keep cavities clean of mortar droppings and other materials during construction. Bevel beds away from cavity, to minimize mortar protrusions into cavity. Do not attempt to trowel or remove mortar fins protruding into cavity.
- C. Installing Cavity-Wall Insulation: Place small dabs of adhesive, spaced approximately 12 inches o.c. both ways, on inside face of insulation boards, or attach with plastic fasteners designed for this purpose. Fit courses of insulation between wall ties and other confining obstructions in cavity, with edges butted tightly both ways. Press units firmly against inside wythe of masonry or other construction as shown. Tape joints and around penetrations with manufacturer's approved tape.

### **3.7 MASONRY JOINT REINFORCEMENT**

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8" on exterior side of walls, 1/2" elsewhere. Lap reinforcement a minimum of 6 inches.
  1. Space reinforcement not more than 16 inches o.c.
  2. Space reinforcement not more than 8 inches o.c. in foundation walls and parapet walls.
  3. Provide reinforcement not more than 8 inches above and below wall openings and extending 12 inches beyond openings in addition to continuous reinforcement.
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.

### **3.8 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE**

- A. Anchor masonry to structural steel and concrete where masonry abuts or faces structural

steel or concrete to comply with the following:

1. Provide an open space not less than 1/2" wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
3. Space anchors as indicated, but not more than 16 inches o.c. vertically and 24 inches o.c. horizontally.

### **3.9 ANCHORING MASONRY VENEERS**

- A. Anchor masonry veneers to concrete, and masonry backup with seismic masonry-veneer anchors to comply with the following requirements:
1. Fasten screw-attached and seismic anchors to concrete and masonry backup with metal fasteners of type recommended by manufacturer. Use two fasteners unless anchor design only uses one fastener.
  2. Embed tie sections connector sections and continuous wire in masonry joints. Provide not less than indicated air space between back of masonry veneer and face of concrete, or masonry backup.
  3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.
  4. Space anchors as indicated, but not more than 16 inches o.c. vertically and 24 inches o.c. horizontally with not less than 1 anchor for each 2.67 sq. ft. of wall area. Install additional anchors within 12 inches of openings and at intervals, not exceeding 36 inches, around perimeter.

### **3.10 ANCHORING MASONRY VENEERS TO STUD FRAMING**

- A. Anchor masonry veneers to wood or metal stud framing backup with seismic masonry-veneer anchors to comply with the following requirements:
1. Place seismic anchor channels on face of rigid cavity wall insulation, fasten by screw-attached method with metal spacer clips through rigid insulation and wall sheathing to wall framing with metal fasteners of type recommended by manufacturer.
  2. Insert wire tie section into channel, embed tie section connector sections and continuous horizontal reinforcement wire (set in tie section seismic clip) in masonry joints. Provide not less than indicated air space between back of masonry veneer and face of sheathing backup. Allow for rigid wall insulation clearance and installation requirements.
  3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.
  4. Space anchors as indicated, but not more than 16 inches o.c. vertically and 24 inches o.c. horizontally with not less than 1 anchor for each 2.67 sq. ft. of wall area. Install additional anchors within 12 inches of openings and at intervals, not exceeding 36 inches, around perimeter.



### **3.11 FLASHING, WEEP HOLES, CAVITY DRAINAGE, AND VENTS**

- A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated.
- B. Install flashing as follows unless otherwise indicated:
  - 1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
  - 2. At lintels and shelf angles, extend flashing a minimum of 6 inches above drainage mat. At heads and sills, extend flashing 6 inches at ends and turn up not less than 2 inches to form end dams.
  - 3. Install stainless steel metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2" back from outside face of wall and adhere flexible flashing to top of stainless steel metal drip edge.
  - 4. Install stainless steel metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2" back from outside face of wall and adhere flexible flashing to top of stainless steel metal flashing termination.
- C. Install weep holes in head joints in exterior wythes of first course of masonry immediately above embedded flashing and as follows:
  - 1. Use specified weep rope products to form weep holes.
  - 2. Provide rope and weeps in head joints in first course at base of wall as well as every location immediately above flashing. Provide at the bottom of head joints, spaced as follows: minimum of 16" o.c. at masonry units which are equal to or less than 8" long; 24" o.c. at masonry units which are 12" long; 16" o.c. at masonry units which are 16" long; 24" o.c. at masonry units which are 24" long.
  - 3. Lay rope on flashing and properly extend rope into cavity and run horizontally behind veneer masonry, below cavity drainage mat.
- D. Place cavity drainage material in cavities to comply with configuration requirements for cavity drainage material in "Miscellaneous Masonry Accessories" Article.

### **3.12 REINFORCED UNIT MASONRY INSTALLATION**

- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
  - 1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
  - 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in ACI 530.1/ASCE 6/ TMS 602.

- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
  - 1. Comply with requirements in ACI 530.1/ASCE 6/TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
  - 2. Limit height of vertical grout pours to not more than 60 inches.

### **3.13 PROTECTION OF WORK AND MATERIAL**

- A. Refer to Project Conditions paragraph 1.06 for further requirements.
- B. Keep wall surfaces and projections free of droppings and mortar smears.
- C. Corners of entrances and jambs and external corners that could be damaged shall be protected by wood and boxing.
- D. Cover masonry units stored on the site, and keep dry until after placed in the wall. Cover tops of walls, projections, openings, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress. Extend cover a minimum of 24 inches down both sides and secure cover in place against high winds, rain, snow, and ice. Concrete masonry shall be thoroughly cured and dry before placement. Keep stored masonry away from contact with the ground.
- E. Do not perform work when the temperature might drop below freezing before initial set without proper protection and procedures as herein described.

### **3.14 COLD WEATHER CONSTRUCTION/PROTECTION**

- A. Cold Weather Construction: Perform the following construction procedures while masonry work is progressing. Temperature ranges indicated below apply to air temperatures existing at time of installation. In heating mortar and grout materials, maintain mixing temperature selected within 10° F. Do not heat water for mortar and grout to above 160° F.
  - 1. 40° F to 32° F.:  
Mortar: Heat sand or mixing water to produce mortar temperature between 40° F. and 120° F.  
Grout: Follow normal masonry procedures.
  - 2. 32° F. to 25° F.:  
Mortar: Heat mixing water and sand to produce mortar temperatures between 40° F. and 120° F.; maintain temperature of mortar until used above freezing.  
Grout: Heat grout materials to 90° F. to produce in-place grout temperature of 70° F.
  - 3. 25° F. to 20° F.:  
Mortar: Heat mixing water and sand to produce mortar temperatures between 40° F. and 120° F.; maintain temperature of mortar until used above freezing.  
Grout: Heat grout materials between 70° F. and 120° F to produce in-place grout temperature of 70° F.

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4. Provide enclosure and auxiliary heat to maintain an air temperature of at least 40° F.
  5. 20° F. and below:  
  
Mortar: Heat mixing water and sand to produce mortar temperatures between 40° F. and 120° F.  
  
Grout: Heat grout materials to 90° F. to produce in-place grout temperature of 70° F.  
  
Masonry Units: Heat masonry units so that they are above 40° F. at time of laying.  
  
Provide enclosure and auxiliary heat to maintain an air temperature of at least 40° F. for 24 hours after laying units.
- B. Cold Weather Protection: These requirements apply after masonry is placed and are based on anticipated minimum daily temperature for grouted masonry and anticipated mean daily temperature for ungrouted masonry. Protect completed masonry in the following manner.
1. 40° F. to 25° F.:  
  
Completely cover masonry with weather-resistive membrane for at least 24 hours.
  2. 25° F. to 20° F.:  
  
Completely cover masonry with weather-resistive insulating blankets or similar protection for at least 24 hours, 48 hours for grouted masonry.
  3. 20° F. and below:  
  
Except as otherwise indicated, maintain masonry temperature above 32° F. for 24 hours using enclosures and supplementary heat, electric heating blankets, infrared lamps or other methods proven to be satisfactory. For grouted masonry maintain heated enclosure to 40° F. for 48 hours.

**3.15 FIELD QUALITY CONTROL**

- A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas, as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.
- B. Inspections: Level 1 special inspections according to the "International Building Code" where the height (H) of masonry or length of masonry (L) to thickness (T) of masonry ratio (H/T or L/T) exceeds 18.
1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
  2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
  3. Place grout only after inspectors have verified proportions of site-prepared grout.

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- C. Testing Prior to Construction: One set of tests.
- D. Testing Frequency: One set of tests for each 5000 sq. ft. of wall area or portion thereof.
- E. Clay Masonry Unit Test: For each type of unit provided, according to ASTM C 67 for compressive strength.
- F. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.
- G. During progress of work, mortar tests shall be made by an approved testing laboratory in accordance with "Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry", A.S.T.M. C 780. Include the cost of tests in contract price.
  - 1. Perform one series of mortar tests for each 10,000 square feet of gross building area.
- H. If the test results indicate that the mortar does not meet specified requirements, Architect shall have the right to request additional tests to be made on portions of the building affected at the Contractor's expense. Should the results of the additional testing fail to meet specified requirements, it is the Contractor's responsibility to remove and replace such faulty masonry work as determined by the Architect.

**3.16 REPAIRING, POINTING, AND CLEANING**

- A. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- B. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
  - 1. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes.
  - 2. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.
  - 3. Clean masonry with a proprietary commercial cleaner applied according to manufacturer's written instructions only if above methods do not achieve approved results.
  - 4. Protect surfaces from contact with cleaner.
  - 5. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
  - 6. Clean concrete masonry by cleaning method indicated in NCMA TEK 8-2A applicable to type of stain on exposed surfaces.

**END OF SECTION 04 2000**

**SECTION 05 1200**

**STRUCTURAL STEEL FRAMING**

**PART 1 – GENERAL**

**1.1 DESCRIPTION**

- A. Structural steel framing.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Structural steel.
  - 2. Grout.

**1.3 DEFINITIONS**

- A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."
- B. Seismic-Load-Resisting System: Elements of structural-steel frame designated as "SLRS" or along grid lines designated as "SLRS" on Drawings, including columns, beams, and braces and their connections.
- C. Heavy Sections: Rolled and built-up sections as follows:
  - 1. Shapes included in ASTM A 6/A 6M with flanges thicker than 1-1/2 inches (38 mm).
  - 2. Welded built-up members with plates thicker than 2 inches (50 mm).
  - 3. Column base plates thicker than 2 inches (50 mm).

**1.4 PERFORMANCE REQUIREMENTS**

- A. Connections: Provide details of connections required by the Contract Documents to be selected or completed by structural-steel fabricator to withstand loads indicated and comply with other information and restrictions indicated.
  - 1. Select and complete connections using schematic details indicated.
  - 2. Use ASD; data are given at service-load level.

**1.5 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication of structural-steel components.
  - 1. Prepare erection drawings, complete with all necessary plans, elevation and sections, to indicate size and relative position of members. Do not reproduce design drawings for use as erection drawings. Include erection drawings with each submittal indicating marks of all members, assemblies and loose pieces included in the submittal.
  - 2. Indicate on details of all pieces, principal column grid lines where members are located.
  - 3. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
  - 4. Include setting drawings and direction for installation of anchor rods and other anchorages embedded in concrete.
  - 5. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.

6. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
  7. Indicate surface preparation as per SSPC and prime painting for each member if specified.
  8. Identify members and connections of the seismic-load-resisting system.
  9. Indicate locations and dimensions of protected zones.
  10. Identify demand critical welds.
  11. For structural-steel connections indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  12. Clearly indicate revisions made on erection drawings and pieces on any re-submittal.
  13. Submit complete shop drawings for fabrication of cables and fittings. Show exact locations, material, sizes and lengths of all cables and fittings. Indicate fabricating and preparation procedures for cables and fittings. Clearly indicate sequence, procedures and method of erection.
- C. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for each welded joint whether prequalified or qualified by testing, including the following:
1. Power source (constant current or constant voltage).
  2. Electrode manufacturer and trade name, for demand critical welds.
- D. Qualification Data: For qualified Installer.
- E. Welding certificates.
- F. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
- G. Mill test reports for structural steel, including chemical and physical properties.
- H. Product Test Reports: For the following:
1. Bolts, nuts, and washers including mechanical properties and chemical analysis.
  2. Welding filler metals and fluxes.
  3. Shear stud connectors.
  4. Shop primers.
- I. Fastener Certification.
1. Submit to the inspection and testing agency and the Architect certified copies of mill test reports for the bolts, nuts and washers from the manufacturer for each shipping lot, complying with the requirements of ASTM A 325/A 325M or ASTM A 490/A 490M, ASTM A 563/A 563M, ASTM F 436/F 436M and ASTM F 959/F 959M.
  2. Submit to inspection and testing agency, a certified statement of compliance that high-strength bolts, nuts and washers furnished under this section meets the specified requirements.
  3. Submit to inspection and testing agency, a certified statement of compliance that welding materials furnished under this section meets AWS requirement.

## **1.6 QUALITY ASSURANCE**

- A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category STD.

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- B. Installer Qualifications: A qualified installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category ACSE.
- C. Employ a steel erector who has had 5 years of successful experience in erection of structural steel and is able to furnish evidence of erector's ability, facilities, proficiency of erector's personnel and completed projects.
- D. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1 or SSPC-QP 3, "Standard Procedure for Evaluating Qualifications of Shop Painting Applicators."
- E. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
  - 1. Welders and welding operators performing work on bottom-flange, demand-critical welds shall pass the supplemental welder qualification testing, as required by AWS D1.8. FCAW-S and FCAW-G shall be considered separate processes for welding personnel qualification.
- F. Comply with applicable provisions of the following specifications and documents:
  - 1. AISC 303.
    - a. Throughout AISC 303, replace "Structural Design Drawings" with "Design Drawings and other Contract Documents".
    - b. Delete paragraph 3.3 – Discrepancies.
    - c. Delete paragraph 4.4 – Approval, and replace with the following:
      - 1) Refer to the Condition of Contract and Section 01330, Submittal Procedures.
      - 2) Review of Shop Drawings by the Architect shall not relieve the Contractor of responsibility for accuracy of detail dimensions, fit of parts assembled in shop or field, ability to erect the material, or other Contract requirements.
      - 3) Notation by the Architect made on the Shop Drawings does not authorize changes to the Contract requirements including Contract sum or Contract time.
    - d. Paragraph 4.6 – The RFI Process: Omit reference to "Revision to the Contract Document".
    - e. Delete paragraph 9.3 – Revisions to Contract Documents.
    - f. Paragraph 9.4 – Contract Price Adjustment, replace with the following:
      - 1) Revision to the Contract Documents and Contract Price Adjustment shall be as per the Condition of Contract.
  - 2. AISC 341 and AISC 341s1.
  - 3. AISC 360.
  - 4. AWS D1.1 "Structural Welding Code", with the exception as listed in AISC 360-05 specification section J2, apply in lieu of AWS provisions and to the following:
    - a. Delete section 5.3.3.4, "Recrushed Slag"
  - 5. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

**1.7 DELIVERY, STORAGE, AND HANDLING**

- A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.
- B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.
  1. Fasteners may be repackaged provided Owner's testing and inspecting agency observes repackaging and seals containers.
  2. Clean and relubricate bolts and nuts that become dry or rusty before use.
  3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.
  4. Do not store material on structure that might cause distortion, damage or overload to members or supporting structures. Repair or replace damaged materials or structures as directed by the Architect.

## **1.8 COORDINATION**

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

## **1.9 PROJECT CONDITIONS**

- A. Measurements:
  1. Make such field measurements as are necessary to lay out the Work properly.
- B. Alteration and Connections to existing steel:
  1. Make all necessary field measurements for detailing, fabricating and installing reinforcing and new members to be connected to existing steel or reworking existing members. Identify conditions prohibiting installation as indicated.

## **PART 2 – PRODUCTS**

### **2.1 STRUCTURAL-STEEL MATERIALS (Unless Noted Otherwise)**

- A. W-Shapes: ASTM A 992.
- B. Channels, Angles Shapes: ASTM A 36
- C. Plate and Bar: ASTM A 36
- D. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B, structural tubing.
- E. Welding Filler Materials, Fluxes and Electrodes: Comply with AWS requirements.

### **2.2 BOLTS, CONNECTORS, AND ANCHORS**

- A. Carbon Steel Bolts: ASTM A 307.
- B. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts;
- C. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
- D. Unheaded Anchor Rods: ASTM F 1554, Grade 36.
  1. Configuration: Hooked.
  2. Nuts: ASTM A 563 hex carbon steel.



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3. Plate Washers: ASTM A 36 carbon steel.
  4. Washers: ASTM F 436, Type 1, hardened carbon steel.
  5. Finish: Plain
- E. Threaded Rods: ASTM A 36.
1. Nuts: ASTM A 563 hex carbon steel.
  2. Washers: ASTM F 436 carbon steel.
  3. Finish: Plain

## **2.3 GROUT**

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

## **2.4 FABRICATION**

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.
1. Camber structural-steel members where indicated.
  2. Fabricate beams with rolling camber up.
  3. All provisions of AWS D1.1 apply to welds.
  4. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
  5. Mark and match-mark materials for field assembly.
  6. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Shop Welding: Perform welding in accordance with approved welding procedures and AWS D1.1, except as modified in Section J2 of AISC 360-05.
1. Enforce and supervise approved procedure for welding during fabrication of structural steel by employing experienced supervisors knowledgeable of good welding practices.
  2. Assemble and weld built-up sections by method that will maintain true alignment of axes without exceeding tolerance of AISC 303-05.
  3. Remove backing bars or run off tabs, back gouge, and grind smooth as per AWS D1.1 requirements.
- C. High Strength Steel Bolting.
1. Joints subjected to fatigue load with reversal of loading direction.
  2. Joints installed in oversized holes.
  3. Joints that utilize slotted hole except those with applied load normal to long dimension of the slot.
  4. Joints in which slip at the faying surface would be detrimental to the performance of the structure.
  5. Joints in which fastener pretension is required in the governing code or specification.
  6. Joints subjected to load reversal.
  7. Joints subjected to fatigue load with no reversal of loading.

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8. Joints with ASTM A325 or F1852 bolts subjected to tensile fatigue. Joints with ASTM (5) A490 bolts that are subjected to tension, or combined shear and tension, with or without fatigue.
    - a. ST joints are permitted for all other application and should be used whenever possible.
    - b. Mixing of A325 and A490 bolts of same diameter should be avoided to assure that bolts are installed in proper locations.
    - c. Do not use A490 bolts larger than one inch diameter in SC joint as torque required to install these is beyond the commonly available wrenches.
    - d. Coordinate and indicate on drawing joint types.
  9. Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A325 or A490 Bolts" for type of bolts and type of joint as indicated.
    - a. Snug tightened joints (ST): Bearing type connections based on allowable stresses with threads included in shear plane (Type N). Faying surfaces and surfaces adjacent to bolt heads and nuts shall be free of dirt and other foreign material.
- D. Anchor Rods (Bolts).
1. Furnish anchor rods (bolts) as indicated to be embedded in concrete, including nuts and washers. Detail anchor rods (bolts) such that the minimum projection above the nut, after the column is in place, is 25 mm (one inch).
- E. Columns and Base Plates.
1. Furnish anchor rods (bolts) as indicated to be embedded in concrete, including nuts and washers. Detail anchor rods (bolts) such that the minimum projection above the nut, after the column is in place, is 25 mm (one inch).
- F. Beams.
1. Provide one-piece beams without splice(s), unless otherwise indicated. Where splices are permitted, splice connections shall develop the strength of the beam.
- G. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
- H. Bolt Holes: Cut, drill, or punch standard bolt holes perpendicular to metal surfaces.
- I. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- J. Cleaning: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 3, "Power Tool Cleaning".
- K. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.
- L. Steel Wall-Opening Framing: Select true and straight members for fabricating steel wall-opening framing to be attached to structural steel. Straighten as required to provide uniform, square, and true members in completed wall framing.
- M. Welded Door Frames: Build up welded door frames attached to structural steel. Weld exposed joints continuously and grind smooth. Plug-weld fixed steel bar stops to frames. Secure removable stops to frames with countersunk machine screws, uniformly spaced not more than 10 inches (250 mm) o.c. unless otherwise indicated.
- N. Holes: Provide holes required for securing other work to structural steel and for other work to pass through steel framing members.

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1. Cut, drill, or punch holes perpendicular to steel surfaces.[ Do not thermally cut bolt holes or enlarge holes by burning.]
  2. Baseplate Holes: Cut, drill, mechanically thermal cut, or punch holes perpendicular to steel surfaces.
  3. Weld threaded nuts to framing and other specialty items indicated to receive other work.
- O. Hollow Structural Steel and Other Closed End Members.
1. Provide hollow structural steel and other closed end members with cap plates with watertight welds at the ends and with weep holes where indicated.
- P. Trusses and Sway Frames.
1. Fabricate trusses as all-welded construction with connections designed in accordance with loads and stresses indicated but in no case less than the requirements of AISC specifications and the following:
    - a. Neutral axes of members: intersect at joints.
    - b. Top and bottom chord of trusses: one piece and without splices unless otherwise indicated.
    - c. Splice connections: meet the approval of the Architect. No holes drilled in a tension member of a truss.
    - d. Camber: 3 mm per 3 meters (1/8 inch per 10 feet) of span, unless otherwise indicated.
  2. Construct sway frames as outlined for trusses.
  3. Bracing.
    - a. Provide diagonal bracing, ties and struts as indicated. Design diagonal bracing in the plane of the truss top chord to be welded or clamped to the bottom flange of the purlins. Support bottom chord horizontal bracing members over 6 meters (20 feet) long at approximately mid span by means of 13-mm-diameter (1/2-inch-diameter) rod hangers to purlins above. Detail ties and bracings for draw.
- Q. Connections for Other Work.
1. Notify other trades so that holes in structural steel can be provided for attachments where required. Provide necessary holes if information is received prior to fabrication.
  2. Make provisions in structural steel for the following:
    - a. Future expansion where shown.
    - b. Connections to existing building where required.
  3. Unless otherwise indicated, holes for attachment of wood blocking: 13 mm (1/2 inch) diameter at 600-mm (24-inch) spacing.

## **2.5 SHOP CONNECTIONS**

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M[ and AWS D1.8/D1.8M] for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Enforce and supervise approved procedure for welding during fabrication of structural steel by employing experienced supervisors knowledgeable of good welding practices.

2. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.
3. Remove backing bars or run off tabs, back gouge and grind smooth as per AWS D1.1 requirements.

## **2.6 SHOP PRIMING**

- A. Shop prime steel surfaces except the following:
  1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches (50 mm).
  2. Surfaces to be field welded.
  3. Surfaces to be high-strength bolted with slip-critical connections.
  4. Surfaces on which metal floor deck shear studs are to be welded.
  5. Crane rails.
  6. Surfaces to receive sprayed fire-resistive materials (applied fireproofing).
  7. Galvanized surfaces.
- B. Surface Preparation: Clean surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
  1. As per Section 09 91 00 – Painting and Finishing
- C. Primer:
  1. As per Section 09 91 00 – Painting and Finishing
- D. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness of 1.5 mils (0.038 mm). Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
  1. Stripe paint corners, crevices, bolts, welds, and sharp edges.
  2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

## **2.7 SOURCE QUALITY CONTROL**

- A. Testing Agency: Owner will engage an independent testing and inspecting agency to perform shop tests and inspections and prepare test reports.
  1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
- B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
- C. Bolted Connections: Shop-bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- D. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
  1. Liquid Penetrant Inspection: ASTM E 165.
  2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
  3. Ultrasonic Inspection: ASTM E 164.

4. Radiographic Inspection: ASTM E 94.
- E. In addition to visual inspection, shop-welded shear connectors will be tested and inspected according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
  1. Bend tests will be performed if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
  2. Tests will be conducted on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.

## **PART 3 – EXECUTION**

### **3.1 EXAMINATION**

- A. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
  1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
  2. Detail the structural steel with a minimum of 1 inch (25 mm) of anchor rod (bolt) thread projecting above the nuts and the base plate hole 1-1/3 times the rod (bolt) diameter. Based on these procedures, the foundations shall be found acceptable if erection can be accomplished within AISC 303-05 tolerances for plumbness and elevation, and with minimum-maximum grout thickness of 1/2 to 2 inches (13 to 50 mm).
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
- B. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.
- C. Design and provide temporary supports, such as guys, bracing, falsework, cribbing or other elements required for steel framework erection, including partly assembled steel framing in consideration of noted interaction items. Design temporary supports to withstand all loads to which the structure may be subjected during erection and subsequent construction, including erection equipment.
- D. Furnish and place all temporary bracing necessary for erection before bolting or welding. Only light drifting will be permitted to draw parts together. Drifting to match unaligned holes will not be permitted. Perform enlargement of holes necessary to make connections resulting from misfit by drilling and reaming; then use the proper size bolt.

### **3.3 ERECTION**

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.
- B. Comply with OSHA 29 CFR 1926, and all University of Illinois requirements for steel erection.
- C. Foundation and anchor rods or bolts are designed for the forces of completed structure. Forces due to erection are the responsibility of the Contractor.
- D. Start steel erection only after concrete in the supporting structure such as footings, piers and walls or mortar in masonry piers and walls has attained minimum 75 percent of intended strength or sufficient strength to support the loads imposed during steel erection.

- E. In planning the method of erection, make full allowance for obstructions encountered which may result from work performed by other trades as well as the operations of the Owner.
- F. In planning the method of plumbing the structure, make allowance for temperature difference between time of erection and mean operating temperature of structure when completed. Take into account differential temperature effects on column lengths in plumbing when tall frames are subjected to strong sun exposure on one side.
- G. Furnish and deliver to the job site anchor rods (bolts), and templates for setting the anchor rods (bolts).
  - 1. Lateral-load-resisting system and connecting diaphragm that provides lateral strength and stability in completed structure.
  - 2. Any special erection considerations that are required by design such as shores, jacks or load that must be adjusted during erection, etc.
- H. All lateral load resistance and stability of the completed structure in each orthogonal direction is provided by braced frames.
- I. Base Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
  - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
  - 2. Weld plate washers to top of baseplate.
  - 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
  - 4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure.
- J. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."
- K. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
  - 1. Level and plumb individual members of structure.
  - 2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
- L. Splice members only where indicated.
- M. Do not use thermal cutting during erection[ unless approved by Architect. Finish thermally cut sections within smoothness limits in AWS D1.1/D1.1M].
- N. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- O. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

### **3.4 FIELD CONNECTIONS**

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
  - 1. Joint Type: Snug tightened

2. Provide a minimum of two (2) rows of bolts for beam connections. Begin connection near top of the web and extend them down to at least one half (1/2) of distance between web toes of fillet at top and bottom of web.
  3. Provide truss connections to column with symmetrical double angles and bolts designed for eccentricity and prying action. Provide minimum of six (6) high strength bolts for truss to truss or truss to column connection.
  4. ASTM A 307 bolts may be used for secondary members such as girts, door frames, parapet frames, small roof openings (less than 600 mm (2'-0" square) and sag rods.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
  2. Field welding will be permitted only where indicated on approved Shop Drawings or where otherwise approved by the Architect. Perform field welding in accordance with the approved welding procedures and AWS D1.1 except as modified in Section J2 of AISC 360-05.
  3. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.
  4. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.
  5. Remove backing bars or runoff tabs, back gouge and grind smooth as per AWS D1.1 requirements.

### 3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will inspect field welds and high-strength bolted connections.
- B. Bolted Connections: Bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Field welds will be visually inspected according to AWS D1.1/D1.1M.
1. In addition to visual inspection, field welds will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
    - a. Liquid Penetrant Inspection: ASTM E 165.
    - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
    - c. Ultrasonic Inspection: ASTM E 164.
    - d. Radiographic Inspection: ASTM E 94.
- D. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
  2. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.
- E. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

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**3.6 REPAIRS AND PROTECTION**

- A. Touchup Painting: Cleaning and touchup painting are specified in Section 09 91 00 Painting and Finishing.

**END OF SECTION 05 1200**



**SECTION 05 21 00**

**STEEL JOIST FRAMING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes the following:

1. K-series steel joists.
2. Joist accessories.

**1.2 DEFINITIONS**

- A. SJI "Specifications": Steel Joist Institute's "Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders."
- B. Special Joists: Steel joists or joist girders requiring modification by manufacturer to support nonuniform, unequal, or special loading conditions that invalidate load tables in SJI's "Specifications."

**1.3 PERFORMANCE REQUIREMENTS**

- A. Structural Performance: Provide special joists and connections capable of withstanding design loads indicated.
- B. Design special joists to withstand design loads with live load deflections no greater than the following:
1. Roof Joists: Vertical deflection of 1/360 of the span.

**1.4 SUBMITTALS**

- A. Product Data: For each type of joist, accessory, and product indicated.
- B. Shop Drawings:
1. Show layout, designation, number, type, location, and spacing of joists.
  2. Include joining and anchorage details, bracing, bridging, joist accessories; splice and connection locations and details; and attachments to other construction.
  3. Indicate locations and details of bearing plates to be embedded in other construction.
  4. Comprehensive engineering analysis of special joists signed and sealed by the qualified professional engineer responsible for its preparation.
- C. Qualification Data: For manufacturer.
- D. Welding certificates.
- E. Manufacturer Certificates: Signed by manufacturers certifying that joists comply with requirements.
- F. Mill Certificates: Signed by bolt manufacturers certifying that bolts comply with requirements.
- G. Field quality-control test and inspection reports.
- H. Research/Evaluation Reports: For joists.

**1.5 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: A manufacturer certified by SJI to manufacture joists complying with applicable standard specifications and load tables of SJI "Specifications."
1. Manufacturer's responsibilities include providing professional engineering services for designing special joists to comply with performance requirements.

- B. Erector Qualifications: Engage an experienced Erector who has completed steel joist work similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance
  - 1. Erector must participate in the AISC Quality Certification Program and be designated an AISC-Certified Steel Erector as follows:
    - a. Category: ACSE
  - 2. In lieu of the Steel Erector having the required Certification, the Contractor must be pre-approved by the Engineer. The Contractor must demonstrate their qualification's by providing documentation of 3 projects in the last 5 years of similar size and construction.
- C. SJI Specifications: Comply with standard specifications in SJI's "Specifications" that are applicable to types of joists indicated.
- D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

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

- A. Deliver, store, and handle joists as recommended in SJI's "Specifications."
- B. Ship, unload, and store materials to permit easy access for inspection and identification. Keep joists off ground and spaced by using pallets, platforms, or other supports and spacers. Protect joists and packaged materials from corrosion and deterioration.
  - 1. Do not store materials on structure in a manner that might cause distortion or damage to members or supporting structures. Repair or replace damaged materials or structures as directed.
  - 2. Steel that becomes soiled or otherwise defaced, shall be washed clean just before erection.
- C. Handle to not damage shop applied coating.

## **PART 2 – PRODUCTS**

### **2.1 MATERIALS**

- A. Steel: Comply with SJI's "Specifications" for web and steel-angle chord members.
- B. Steel Bearing Plates: ASTM A 36/A 36M.
- C. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy hex steel structural bolts; ASTM A 563 heavy hex carbon-steel nuts; and ASTM F 436 hardened carbon-steel washers.
  - 1. Finish: Plain.
- D. Welding Electrodes: Comply with AWS standards.

### **2.2 PRIMERS**

- A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Primer: SSPC-Paint 15, or manufacturer's standard shop primer complying with performance requirements in SSPC-Paint 15.

### **2.3 K-SERIES STEEL JOISTS**

- A. Manufacture steel joists of type indicated according to "Standard Specifications for Open Web Steel Joists, K-Series" in SJI's Specifications, with steel-angle top- and bottom-chord members, Top Chord Single or Double Pitched Underslung with flat bottom chords.
  - 1. Joist Type: K-series steel joists and KCS-type K-series steel joists.
- B. Steel Joist Substitutes: Manufacture according to "Standard Specifications for Open Web Steel Joists, K-Series" in SJI's "Specifications," with steel-angle or -channel members.
- C. All joists shall have the same web and panel point configuration and dimensions, so as to allow minor piping and conduit, oriented perpendicular to joist, to run straight through from joist to joist.
- D. Comply with AWS requirements and procedures for shop welding, appearance, quality of welds, and methods used in correcting welding work.
- E. Provide holes in chord members for connecting and securing other construction to joists.
- F. Top-Chord Extensions: Extend top chords of joists with SJI's Type S top-chord extensions where indicated, complying with SJI's "Specifications."
- G. Extended Ends: Extend bearing ends of joists with SJI's Type R extended ends where indicated, complying with SJI's "Specifications."
- H. Do not camber joists.
- I. Equip bearing ends of joists with manufacturer's standard beveled ends or sloped shoes if joist slope exceeds 1/4 inch per 12 inches.

## **2.4 JOIST ACCESSORIES**

- A. Bridging: Provide bridging anchors and number of rows of horizontal or diagonal bridging of material, size, and type required by SJI's "Specifications" for type of joist, chord size, spacing, and span. Furnish additional erection bridging if required for stability.
- B. Supply ceiling extensions, either extended bottom-chord elements or a separate extension unit of enough strength to support ceiling construction. Extend ends to within 1/2 inch of finished wall surface, unless otherwise indicated.
- C. Supply miscellaneous accessories, including splice plates and bolts required by joist manufacturer to complete joist installation.

## **2.5 CLEANING AND SHOP PAINTING**

- A. Clean and remove loose scale, heavy rust, and other foreign materials from fabricated joists and accessories by hand-tool cleaning, SSPC-SP 2 or power-tool cleaning, SSPC-SP 3.
- B. Apply 1 coat of shop primer to joists and joist accessories to be primed to provide a continuous, dry paint film not less than 1 mil thick.
  - 1. Unpainted steel at will not be accepted.

## **PART 3 – EXECUTION**

### **3.1 EXAMINATION**

- A. Examine supporting substrates, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance.
  - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Do not install joists until supporting construction is in place and secured.

- B. Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Specifications," joist manufacturer's written recommendations, and requirements in this Section.
  - 1. Space, adjust, and align joists accurately in location before permanently fastening.
  - 2. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
  - 3. Delay rigidly connecting bottom-chord extensions to columns or supports until dead loads have been applied.
  - 4. Joist shall be erected so that the web and panel point configuration and dimensions shall match.
    - a. Joists found in the field not to web and panel point configuration will be re-erected at no expense to the Owner.
- C. Field weld joists to supporting steel framework. Coordinate welding sequence and procedure with placement of joists. Comply with AWS requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
- D. Bolt joists to supporting steel framework using high-strength structural bolts. Comply with RCSC's "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts"
  - 1. Bolts: ASTM A 325 high-strength bolts, unless otherwise indicated.
  - 2. Connection Type: Snug tightened, unless indicated as slip-critical, direct-tension, tension control or tensioned shear/bearing connections.
  - 3. Twist-off type tension control bolt pre-tensioning.
    - a. Twist-off type tension control bolt assemblies shall be in accordance with ASTM F1852.
    - b. Before final tightening of joint, properly assemble the several parts of joint to snug-tight condition. When installing multi-bolt joints, tighten bolts in stages without breaking off spline to prevent or minimize slackening of installed bolts. Tighten bolts to snug-tight condition at which point faying surfaces of joint should be firmly in contact.
    - c. When bolts in connection are in snug-tight condition, tighten bolts until spline drive shears off. Accomplish final tightening by working progressively away from the fixed or most rigid point of connection to free edge.
    - d. Inspection shall ensure spline drives have been sheared off.
    - e. Eject sheared ends and store in safe place until they can be recycled.
- E. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

### **3.3 FIELD QUALITY CONTROL**

- A. Testing Agency: Construction Manager will engage a qualified independent testing and inspecting agency to inspect field welds and bolted connections and to perform field tests and inspections and prepare test and inspection reports.
- B. Field welds will be visually inspected according to AWS D1.1/D1.1M.
- C. In addition to visual inspection, field welds will be tested according to AWS D1.1/D1.1M following procedures, as applicable:
  - 1. Liquid Penetrant Inspection: ASTM E 165.
  - 2. Magnetic Particle Inspection: ASTM E 709.

3. Ultrasonic Testing: ASTM E 164.
4. Radiographic Testing: ASTM E 94.
- D. Bolted connections will be visually inspected.
- E. High-strength, field-bolted connections will be tested and verified according to procedures in RCSC's "Specification for Structural Joints Using ASTM A 325 or ASTM A 490 Bolts."
- F. Correct deficiencies in Work that test and inspection reports have indicated are not in compliance with specified requirements.
- G. Additional testing will be performed to determine compliance of corrected Work with specified requirements.
- H. A final plumbness survey and building elevation survey will be performed with results submitted to the Owner. Any deficiencies found will need to be corrected by installer.

### **3.4 REPAIRS AND PROTECTION**

- A. Repair damaged galvanized coatings on galvanized items with galvanized repair paint according to ASTM A 780 and manufacturer's written instructions.
- B. Wash and clean steel prior to erection and/or after erection to Owner's satisfaction. All dirt and debris from staging and steel erection activities will need to be cleaned.
- C. Touchup Painting: After installation, promptly clean, prepare, and prime or re-prime field connections, rust spots, and abraded surfaces of prime-painted joists abutting structural steel, and accessories.
  1. Clean and prepare surfaces by hand-tool cleaning, SSPC-SP 2, or power-tool cleaning, SSPC-SP 3.
  2. Apply a compatible primer of same type as shop primer used on adjacent surfaces.
- D. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer that ensure that joists and accessories are without damage or deterioration at time of Substantial Completion.

### **3.5 PAYMENT**

- A. The cost of this work shall be considered incidental to the contract lump sum price for the project.

**END OF SECTION 05 2100**



**SECTION 05 31 00**

**STEEL DECKING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Steel deck and accessories.
  - 2. Formed steel closure plates, eave, ridge and valley plates, and cant strips.
  - 3. Framing for openings up to and including 18-inches.
  - 4. Bearing plates and anchors.
  - 5. Roof drain sump pans.

**1.2 REFERENCES**

- A. ASTM International (ASTM):
  - 1. ASTM A36 - Structural Steel.
  - 2. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - 3. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic Coated by the Hot-Dip Process.
  - 4. ASTM A992 - Steel for Structural Shapes For Use in Building Framing.
  - 5. ASTM A1008 – Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
- B. American Welding Society (AWS):
  - 1. AWS D1.1 - Structural Welding Code.
  - 2. AWS D1.3 - Structural Welding Code: Sheet Steel.
- C. Factory Mutual (FM):
  - 1. FM - Roof Assembly Classifications.
- D. Steel Deck Institute (SDI):
  - 1. SDI - Design Manual for Composite Decks, Form decks, Roof Decks, Cellular Metal Floor Deck with Electrical Distribution.
- E. The Society for Protective Coatings (SSPC):
  - 1. SSPC - Painting Manual. SSPC Paint No. 15, Steel Joist Shop Paint Type 1, red oxide; SSPC - 20 Type I Inorganic; and SSPC - 20, Type II - Organic.

**1.3 PERFORMANCE REQUIREMENTS**

- A. Design metal deck in accordance with SDI Design Manual.
- B. Calculate to structural working stress design and maximum vertical deck deflection of 1/240.
- C. Design deck with maximum lateral diaphragm deflection of H/400 of wall height.

**1.4 SUBMITTALS**

- A. Division 01 – “General Requirements”: Submittal requirements.

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- B. Shop Drawings: Indicate deck plan, support locations, projections, openings and reinforcement, pertinent details and accessories, fasteners and fastener pattern diagram.
- C. Product Data: Submit deck profile characteristics and dimensions, structural properties, and finishes.
- D. Manufacturer's Installation Instructions: Submit manufacturer's installation instructions.
- E. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
- F. Welders Certificates: Certify welders employed on Work verifying AWS qualification within previous twelve months.

**1.5 QUALIFICATIONS**

- A. Installer: Company specializing in performing work of this Section with minimum five (5) years documented experience.
- B. Design metal decking including layout, spans, fastening, and joints under direct supervision of Structural Engineer experienced in design of this Work and licensed in State of Illinois.

**1.6 DELIVERY, STORAGE AND HANDLING**

- A. Division 01 – "General Requirements": Product Storage and handling requirements.
- B. Cut plastic wrap to encourage ventilation.
- C. Site Storage: Separate sheets and store off ground on dry wood sleepers with one end elevated to provide positive drainage. Protect from elements with a waterproof covering, ventilated to avoid condensation.

**PART 2 – PRODUCTS**

**2.1 MANUFACTURERS**

- 1. Epic Metals Corp.
- 2. United Steel Deck, Inc.
- 3. Vulcraft Steel Deck, Division of Nucor Corp.
- 4. Wheeling Corrugating Co.
- 5. No Substitutions permitted.

**2.2 MATERIALS**

- A. Sheet Steel: ASTM A653, Grade B Structural Quality; with G90 galvanized coating conforming to ASTM A653 and A924.
- B. Sheet Steel: ASTM A1008, Structural Steel (SS), Grade 33, Structural Quality; prime coated both sides.
- C. Bearing Plates and Angles: ASTM A992 steel.
- D. Angles, Plates, and Channels: ASTM A36.
- E. Welding Materials: AWS D1.1.
- F. Fasteners: Carbon steel, self-tapping screws. Framing connections - #12 minimum; deck stitch connections - #10 minimum.
- G. Welding Materials: AWS D1.1 and D1.3.
- H. Shop and Touch Up Primer: SSPC, Type 1, Gray oxide primer to match prime paint of roof deck.
- I. Touch-Up Primer for Galvanized Surfaces: SSPC 20 Type I - Inorganic.
- J. Framed Openings: ASTM A992 Structural Steel;  $F_y = 50$  ksi.



## **2.3 ACCESSORIES**

- A. Flute Closures: Closed cell foam rubber, one (1) inch thick; profiled to fit tight to deck.

## **2.4 FABRICATION**

- A. Metal Deck: Sheet Steel, configured as follows:
  - 1. Span Design: Multiple. Triple span where possible.
  - 2. Minimum Metal Thickness Excluding Finish: 20 gage.
  - 3. See Drawing for Deck Height.
  - 4. Side Joints: Lapped.
  - 5. Flute Sides: Plain vertical face.
- B. Metal Closure Strips, Wet Concrete Stops, Cover Plates, and Cant Strips: 20 gage thick minimum galvanized sheet steel; of profile and size as required.
- C. Roof Sump Pan: Fabricate of 14 gage thick sheet steel, flat bottom, sloped sides, recessed 1- 1/2 inches below roof deck surface, bearing flange 3 inches wide, sealed watertight.
- D. Cant Strips: Formed sheet steel, 20 gage thick, 45 degree slope, 3-1/2 inch nominal width and height, galvanized with 2 inch flange for attachment.
- E. Fasteners: Galvanized hardened steel, self-tapping, painted to match deck pre-coating color.

## **PART 3 – EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that field conditions are acceptable and are ready to receive work.
- B. Beginning of installation means installer accepts existing conditions.

### **3.2 INSTALLATION**

- A. Erect metal deck in accordance with SDI Design Manual.
- B. Bear deck on masonry or concrete support surfaces with four (4) inch minimum bearing. Align and level.
- C. Bear deck on steel supports with 1-1/2-inch minimum bearing. Align and level.
- D. Fasten ribbed deck to steel support members at ends and intermediate supports with fusion welds at 12 inches on center maximum spacing. Parallel with deck flute and at each transverse flute.
- E. Welded connections shall be in accordance with AWS D1.1 and D1.3.
- F. Mechanically fasten male/female side laps at 24 inches on center maximum.
- G. Stitch fastening of deck shall be made with minimum #10 self-tapping screws.
- H. Mechanically fasten side laps, as a minimum, at mid-span for 4'-0" and 5'-0" spans and at 36 inches on center for spans over 5'-0".
- I. Reinforce steel deck openings from 6 to 18 inches in size with 2-inch x 2-inch x 1/4-inch steel angles. Place angles perpendicular to flutes; extend minimum two flutes beyond each side of opening and fusion weld or mechanically attach to deck at each flute.
- J. Install six (6) inch minimum wide sheet steel cover plates, of same thickness as deck, where deck changes direction. Fusion weld 12 inches on center maximum.
- K. Install wet concrete stops at roof edge upturned to top surface of slab to contain wet concrete. Install stops of sufficient strength to remain stationary under wet concrete without distortion.

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- L. Install sheet steel closures and angle flashing to close openings between deck and walls, columns, and openings.
- M. Install single row of foam flute closures above walls and partitions perpendicular to deck flutes.
- N. Position roof sump pans with flange bearing on top surface of deck. Fusion weld fasten at each deck flute.
- O. Place metal cant strips in position and mechanically attach or fusion weld.
- P. Immediately after any welding of deck and other metal components in position, clean and coat welds, burned areas, and damaged surface coating, with touch-up prime paint.

**3.3 PAYMENT**

- A. The cost of this work shall be considered incidental to the contract lump sum price for the project.

**END OF SECTION 05 3100**

**SECTION 05 4000**

**COLD-FORMED METAL FRAMING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Steel stud exterior wall framing.
  - 2. Formed steel ceiling framing and bridging.

**1.2 REFERENCES**

- A. American Institute of Steel Construction (AISC):
  - 1. AISC – Steel Construction Manual, Current Edition.
- B. American Iron and Steel Institute (AISI):
  - 1. AISI 2012 S200 Series.
- C. American Society of Civil Engineers (ASCE):
  - 1. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.
- D. ASTM International (ASTM):
  - 1. ASTM A90 - Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
  - 2. ASTM A370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
  - 3. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
  - 4. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
  - 5. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic- Coated by the Hot-Dip Process.
  - 6. ASTM A1003 - Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic- Coated for Cold-Formed Framing Members.
  - 7. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
  - 8. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
  - 9. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
  - 10. ASTM C955 - Standard Specification for Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing or Bridging for Screw Application of Gypsum Panel Products and Metal Plaster Bases.
  - 11. ASTM C1007 - Standard Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories.
  - 12. ASTM C1513 - Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections.

13. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
  14. ASTM E329 - Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.
  15. ASTM E548 - Standard Guide for General Criteria Used for Evaluating Laboratory Competence.
- E. American Welding Society (AWS):
1. AWS D1.1 - Structural Welding Code - Steel.
  2. AWS D.1.3 - Structural Welding Code - Sheet Steel.
- F. The Society for Protective Coatings (SSPC):
1. SSPC Paint 15 - Steel Joist Shop Paint.
  2. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic and Type II - Organic).

### **1.3 SYSTEM DESCRIPTION**

- A. Size components to withstand design loads as indicated on the Drawings.
- B. Maximum Allowable Deflections:
1. Exterior or Interior Non-Load-Bearing Curtain-Wall Framing: Horizontal deflection of  $L/360$  of the wall height.
  2. Exterior or Interior Non-Load-Bearing Curtain-Wall Framing Behind Brick/Masonry: Horizontal deflection of  $L/600$  of wall height (0.3-inch maximum).
  3. Soffit/Ceiling Joist Framing: Vertical deflection of  $L/360$  of the span.
- C. Wall System:
1. Design to AISI 2012 S200 Series.
  2. Design to provide for movement of components without damage, failure of joint seals, undue stress on fasteners, or other detrimental effects when subject to seasonal or cyclic day/night temperature ranges.
  3. 1/4-inch maximum deflection at window head or sill.
  4. 1/8-inch maximum differential deflection at discontinuities and corners.
  5. Design system to accommodate construction tolerances, deflection of building structural members, and clearance of intended openings.
  6. Seismic Loads: Design and size components to withstand seismic loads and sway displacement as calculated in accordance with applicable code.
  7. Design exterior non-load-bearing curtain-wall framing to accommodate horizontal deflection without regard for contribution of sheathing materials.
  8. Design exterior load-bearing (axially loaded) studs to accommodate axial loads without regard for contributions of exterior or interior sheathing materials.
- D. Provide members with minimum properties shown below:
1. Minimum 18-gauge thick sheet steel.

### **1.4 SUBMITTALS**

- A. Design Data: Shop Drawings shall be prepared under supervision of a Structural Engineer licensed in the State of Illinois.
- B. Shop Drawings:

1. Indicate component details, framed openings, bearing, anchorage and hold down devices, loading, strapping, bracing, bridging and blocking, welds, type and location of fasteners, and accessories or items required of related work.
  2. Indicate wall stud, ceiling joist, layout, using cross sections, plans and/or elevations to show spacing, sizes and thickness.
  3. Describe method for securing studs and joists to tracks and for welded or screwed framing connections.
  4. Submit calculations for loadings and stresses of wall studs and joists under Structural Engineer's seal and signature. Include deflection requirements and connection components.
- C. Product Data: Submit data on standard framing members; describe materials and finish, product criteria and limitations.
- D. Manufacturer's Installation Instructions: Submit special procedures and perimeter conditions requiring special attention.
- E. Mill Certifications: Submit mill certifications for steel delivered to site. Certify steel bare metal thickness in 0.001 inch, yield strength, tensile strength, total elongation in 2 inch or 8-inch gauge length, chemical analysis, and galvanized coating thickness.

#### **1.5 QUALITY ASSURANCE**

- A. Calculate structural properties of framing members in accordance with AISI 2012 S200 Series.
- B. Comply with AISI S230 "Standard for Cold-Formed Steel Framing - Prescriptive Method for One and Two Family Dwellings."
- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM E329 to conduct testing as specified in this Section, and as documented according to ASTM E548.
- D. Fire-Test-Response Characteristics: Where metal framing is part of a fire-resistance-rated assembly, provide framing identical to that of assemblies tested for fire resistance per ASTM E119 by a testing and inspecting agency acceptable to authorities having jurisdiction.
1. Fire-Resistance Ratings: Indicated by GA File Numbers in GA-600, "Fire Resistance Design Manual," or by design designations from UL's "Fire Resistance Directory" or from the listings of another testing and inspecting agency.
- E. Preinstallation Conference: Upon request of Architect or Engineer, conduct conference at Project site to comply with requirements stated within Division 01.

#### **1.6 QUALIFICATIONS**

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five (5) years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum five (5) years documented experience.
- C. Design structural elements under direct supervision of Structural Engineer experienced in design of this Work and licensed in State of Illinois.
- D. Owner's testing agency may spot check weldments and welding procedures per AWS standards. This inspection is not intended to be comprehensive or complete. Contractor is solely responsible for total quality control.

#### **1.7 COORDINATION**

- A. Division 01 – "General Requirements": Coordination and project conditions.

## **1.8 DELIVERY, STORAGE AND HANDLING**

- A. Division 01 – “General Requirements”: Product Storage and handling requirements.
- B. All materials delivered to site shall be stored to prevent bending, buckling or twisting.
- C. Protect materials using impervious cover to prevent water or snow from collecting in members.
- D. Protect from elements with a waterproof covering, ventilated to avoid condensation.

## **PART 2 – PRODUCTS**

### **2.1 COLD-FORMED METAL FRAMING**

- A. Framing Manufacturers:
  - 1. Clark Steel Framing Systems Company.
  - 2. Clark/Dietrich Building Systems.
  - 3. Nuconsteel, A Nucor Company.
  - 4. SCAFCO Steel Stud Company
  - 5. Dale/Incor Industries, Inc.
  - 6. Dietrich Industries, Inc.
  - 7. Harrison Manufacturing Company.
  - 8. MarinoWare, Division of Ware Industries, Inc.
  - 9. Steel Network, Inc.
  - 10. Steeler, Inc.
  - 11. Unimast Incorporated.
  - 12. Substitutions: In accordance with Division 01 - General Requirements.

### **2.2 PERFORMANCE REQUIREMENTS**

- A. Structural Performance: Provide cold-formed steel framing capable of withstanding design loads within limits and under conditions indicated.
  - 1. Design Loads: As indicated on Drawings.

### **2.3 FRAMING MATERIALS**

- A. Studs: ASTM A1003, Structural Grade, Type H, sheet steel, zinc-coated, formed to channel shape, ST50H Grade, solid or punched web; minimum 0.048-inch-thick, minimum 1-1/2 inch face and minimum 3-1/2 inch depth.
- B. Joists: ASTM A1003, Structural Grade, Type H, sheet steel, zinc-coated, formed to channel shape, ST50H Grade, solid or punched web; minimum 0.048-inch-thick, minimum 1-1/2 inch face and minimum 8 inch depth.
- C. Track: ASTM A1003, Structural Grade, Type H, formed steel; channel shaped; same material type and width as studs, tight fit; minimum 0.048 inch thick, solid web.
- D. Framing Materials: Roll from new sheet steel; cold reduction steels not being acceptable.
- E. For minimum section properties of all members, reference Article 1.3 “System Description” paragraphs within this Section.
- F. All sizes listed above are minimum sizes and thicknesses. Final member size and spacing are to be determined by light gage engineer and identified in shop drawings and calculations.

## **2.4 ACCESSORIES**

- A. Bracing, Furring, Bridging: Formed sheet steel, thickness determined by performance requirements specified.
- B. Plates, Gussets, Clips: Formed sheet steel, thickness determined by performance requirements specified.
- C. Touch-Up Primer for Galvanized Surfaces: SSPC Paint 20 Type I Inorganic or Type II Organic zinc rich.

## **2.5 FASTENERS**

- A. Self-drilling, Self-tapping Screws, Bolts, Nuts, and Washers: Steel, hot dip galvanized to ASTM A123 1.25 oz./sq. ft.
- B. Anchorage Devices: Powder actuated, drilled expansion bolts, or screws with sleeves.
- C. Welding: In conformance with AWS D1.1 and AWS D1.3.

## **2.6 FABRICATION**

- A. Fabricate assemblies of formed sections of sizes and profiles required, plumb, square and true to line, with connections securely fastened.
- B. Fit, reinforce, and brace framing members to suit design requirements.
- C. Fit and assemble in largest practical sections for delivery to site, ready for installation, but attached to prevent racking and withstand all handling and erection stresses.
- D. Fabrication Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 feet (1:960) and as follows:
  - 1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.
  - 2. Squareness: Fabricate each cold-formed metal framing assembly to a maximum out-of-square tolerance of 1/8 inch.
- E. Fabricate extensions for soffits and ceilings where necessary.

## **2.7 FINISHES**

- A. Studs: Galvanize to G60 coating class.
- B. Tracks and Headers: Galvanize to G60 coating class.
- C. Joists: Galvanize to G60 coating class.
- D. Bracing, Furring, and Bridging: Same finish as framing members.
- E. Plates, Gussets, and Clips: Same finish as framing members.
- F. Galvanizing Repair Paint: SSPC-Paint 20.

## **PART 3 – EXECUTION**

### **3.1 EXAMINATION**

- A. Division 01 – “General Requirements”: Coordination and project conditions.
- B. Verify substrate surfaces and building framing components are ready to receive Work.
- C. Verify rough-in utilities are in proper location.
- D. Notify Engineer/Architect of any discrepancies and resolve before installation begins.

### **3.2 ERECTION OF STUDS**

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- A. Align floor and ceiling tracks; locate to wall and partition layout. Secure in place with fasteners at maximum 16 inches oc.
- B. Place studs at 16 inches oc minimum or as required; not more than 2 inches from abutting walls and at each side of openings. Connect studs to tracks using clip and tie or fastener method. Align studs and tracks with exterior wall cladding elements as shown per drawings.
- C. Construct corners using minimum three studs. Double stud wall openings, door jambs, and window jambs, unless additional studs are required as determined by performance requirements specified.
- D. Erect load bearing studs one piece full length. Splicing of studs is not permitted.
- E. Erect load bearing studs level and square, brace, and reinforce to develop full strength, to achieve design requirements.
- F. Fully seat axial loaded studs in receiving tracks (maximum 1/8-inch gap between stud and track web).
- G. Coordinate placement of insulation in multiple stud spaces after erection.
- H. Install intermediate studs above and below openings to align with wall stud spacing.
- I. Install studs with deflection allowance in stud track, directly below horizontal building framing at non-load bearing framing.
- J. Attach cross studs to studs for attachment of fixtures anchored to walls.
- K. Install framing between studs for attachment of mechanical and electrical items, and to prevent stud rotation.
- L. Touch-up field welds and damaged galvanized surfaces with zinc rich coating.

**3.3 ERECTION TOLERANCES**

- A. Division 01 – “General Requirements”: Tolerances.
- B. Maximum Variation from Indicated Position: One (1) inch.
- C. Maximum Variation of Members from Plane: 1/8-inch.

**3.4 PAYMENT**

- A. The cost of this work shall be considered incidental to the contract lump sum price for the project.

**END OF SECTION 05 4000**



**SECTION 05 5000  
METAL FABRICATIONS**

**PART 1 - GENERAL**

**1.1 WORK INCLUDES**

- A. Provide labor, materials, equipment and incidentals required for the completion of work shown on the drawings and/or specified in this section.
- B. Shop fabricated metal railings, posts, guardrail assemblies, pipe bumpers, wall mounted ladders, ladder platforms, trash enclosure gate structure, stainless steel fabrications, etc.

**1.2 REFERENCES**

- A. American Society for Testing and Materials (ASTM):
  - 1. A36 - Specification for Structural Steel
  - 2. A53 - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coted Welded and Seamless.
  - 3. A307 - Specification for Carbon Steel Externally Threaded Standard Fasteners.
  - 4. A325 - Specification for High-Strength Bolts for Structural Steel Joints.
  - 5. A386 - Specification for Zinc Coating (Hot-Dip) on Assembled Steel Products.
  - 6. A500 - Specification for Cold-Formed Welded and Seamless Carbon Steel structural Tubing in Rounds and Shapes.
  - 7. A501 - Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
- B. American Welding Society (AWS): D.1.1. - Structural Welding Code.

**1.3 QUALITY ASSURANCE**

- A. Fabricator Qualifications:
  - 1. Minimum three (3) years documented experience in successful fabrication of metal work of comparable size and complexity as this project. Submit names, addresses and telephone numbers of owners, architects, engineers and project locations.
- B. Regulatory Requirements:
  - 1. Comply with the Illinois Steel Products Procurement Act, as amended (Illinois Revised statutes, ch. 48, par. 1801 et seq.).
- C. Applicable building code IBC 2015 edition.
- D. Structural Performance: Design, engineer, fabricate, and install the following metal fabrications to withstand code required structural loads and at a minimum the following indicated structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Apply each load to produce the maximum stress in each respective component of each metal fabrication.

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1. Top Rail of Guardrail Systems:
  - a. Concentrated load of 300 lbf applied at any point nonconcurrently, vertically downward, or horizontally.
  - b. Uniform load of 100 lbf per linear foot applied nonconcurrently, vertically downward or horizontally.
  - c. Concentrated and uniform loads above need not be assumed to act concurrently.
2. Handrails Not Serving as Top Rails:
  - a. Concentrated load of 250 lbf applied at any point nonconcurrently, vertically downward or horizontally.
  - b. Uniform load of 50 lbf per linear foot applied nonconcurrently, vertically downward or horizontally.
  - c. Concentrated and uniform loads above need not be assumed to act concurrently.
3. Infill Area of Guardrail Systems:
  - a. Horizontal concentrated load of 200 lbf applied to an area of one square foot at any point in the system including panels, intermediate rails, balusters, or other elements composing the infill area.
  - b. Above load need not be assumed to act concurrently with uniform horizontal loads on top rails of railing systems in determining stress on guard.
4. Guardrails must be designed to meet at a minimum the design loads, and applicable codes and standards requirements.
5. Ladder platforms at a minimum shall be capable of sustaining 200 psf uniform load without deflection.
6. Treads of Steel Stairs:
  - a. Uniform load of 100 lbf per square foot or a concentrated load of 300 lbf on an area of 4 square inches located in the center of the tread, whichever produces the greater stress without deflection.
7. Platforms of Steel Stairs:
  - a. Uniform load of 100 lbf per square foot without deflection.

**1.4 SUBMITTALS**

- A. Shop Drawings:
  1. Indicate profiles, sizes, connection attachments, concealed anchorage methods, reinforcing, anchorage, size and type of fasteners, and accessories.
  2. Include erection drawings, elevations, and details where applicable.
  3. Indicate welded connections using standard AWS welding symbols. Indicate net weld lengths.

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4. In addition, for custom stainless steel fabrications indicate details of construction and installation including concealed anchorage, exposed edge treatments, relation to surrounding work, etc.
- B. Fabricator Qualifications: Submit fabricator's qualification documentation in accord with 1.04.A.
- C. Welder Qualifications: Evidence that welders employed in the work are currently certified under American Welding Society (AWS) qualification procedures.
- D. Product Data: Producer's or manufacturer's information for products as follows, including sufficient data to show compliance with specified requirements:
  1. Primer paint, including manufacturer's data on chemical composition, and dry film thickness per applied coat.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Structural steel materials: Standard Specifications for steel ASTM A572, Grade 50 with special requirements per AISC Technical Bulletin #3 March 1997 (ATSM A992).
- B. Cold-Formed Hollow Structural Sections: ASTM A500, Grade B, structural tubing.
- C. Channels, Angles, Plates: ASTM A36.
- D. Steel Pipe: ASTM A53, Type E or S, Grade B, Schedule 40.
- E. Stainless Steel:
  1. Sheets shall be 14 gauge, 18/8, Type 302, No. 4 finish and be uniform in appearance throughout.
  2. Tubing shall be welded or seamless, 16 gauge, 18/8, Type 302, No. 4 finish.
- F. Bolted field connections: AISC Specifications for structural joints using ASTM A325 bolts.
- G. Metal Primer: Fabricator's standard low-VOC rust inhibiting primer, gray. Coordinate with the specified finish coats to assure compatibility.
- H. Anchor bolts: ASTM A36 carbon steel with ASTM A36 plate washers.
- I. Welding Electrodes: Comply with AWS requirements.

### **2.2 STAINLESS STEEL FABRICATIONS**

- A. Stainless steel counters, sills at wall openings, jamb closures, etc. shall be of one-piece welded construction, including field joints. Enclose ends where exposed. Secure in a concealed manner to a full wood nailer and plywood substrate; or a perimeter 14 gauge galvanized steel channel frame cross-braced not farther than 24" on center. Fasten top to steel channel frame with concealed stud bolts and stainless steel cap nuts with lock washers. Framing for drainboards and dish tables shall be stainless steel.
- B. If installation will be subject to heat, coat underside of tops with a minimum 1/16" thick NSF approved, hard-drying, sound-deadening, mastic material.
- C. Backsplashes shall be integral with top, turned up 4" and back on a 45 degree angle for an additional 2" in height and then down 1", secured to adjacent walls with "Z" clips, and

be fully closed where exposed to view on sides or rear.

### **2.3 WALL MOUNTED LADDERS**

- A. Provide wall mounted ladders as indicated on drawings. Exterior located items to be hot dipped galvanized after fabrication.
  - 1. Comply with the requirements of authorities having jurisdiction and ANSI A14.3.
  - 2. Provide continuous structural steel flat bar side rails with eased edges, spaced 18" clear.
  - 3. Provide solid structural steel bar rungs as indicated, equally spaced, having non-slip top surface.
  - 4. Fit rungs in centerline of side rails, plug weld and grind smooth on outer rail faces.
  - 5. Support each ladder at top and bottom and at intermediate points spaced not more than 4'-0" o.c. Provide each rung with welded or bolted steel brackets, designed for adequate support and anchorage, and to hold the ladder clear of the wall surface with a minimum of 8" clearance from wall or obstruction to centerline of rungs. Secure to wall with two anchors per bracket.
  - 6. Exterior ladders extend side rails 42 inches above top rung or coping, widened to 24" clear, and return rails to wall or gooseneck to structure as indicated.
  - 7. Steel platforms at indicated ladders to be 14 gauge galvanized steel with serrated non-slip surface, and perimeter steel angle frame welded to rungs. Provide any necessary stiffeners, plates, etc. for a complete installation.
- B. Coordinate requirements for interior unit with roof hatch assembly and associated ladder safety post for a complete and proper functional installation.
- C. Provide indicated ladders with lockable 8'-0" galvanized steel security panel to prevent unauthorized access. Panel to cover full width of ladder, provided with heavy gauge continuous hinge allowing for full offset opening for unimpeded access when unlocked and swung aside. Provide with heavy duty padlock hasp for Owners heavy duty security padlock.

### **2.4 METAL RAILINGS AND GUARDRAILS**

- A. Provide metal railings and guardrails as indicated on drawings. Exterior located items to be hot dipped galvanized after fabrication.
- B. Handrails to meet ADA/IAC requirements.

### **2.5 STEEL AND IRON FINISHES**

- A. Shop Painting:
  - 1. Shop paint ferrous metalwork except surfaces and edges to be field welded (and those indicated to be galvanized).
  - 2. Remove scale, rust and other deleterious materials before the shop coat of paint is applied. Remove oil, grease and similar contaminants in accordance with SSPC SP-1 "Solvent Cleaning." Clean off heavy rust and loose mill scale in accordance with SSPC SP-2 "Hand Tool Cleaning," SSPC SP-3 "Power Tool Cleaning," or SSPC SP-7 "Brush-Off Blast Cleaning." Steel that is to receive

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organic zinc-rich primer shall be cleaned in accordance with SSPC-4 SP-6 "Commercial Blasting."

3. Apply one shop coat of metal primer paint to fabricated metal items, except apply two (2) coats of paint to surfaces which are inaccessible after assembly or erection. Change color of second coat to distinguish it from the first.
  4. Immediately after surface preparation, brush or spray on metal primer paint, applied in accordance with the manufacturer's instructions and at a rate to provide a uniform, dry film thickness of 2.0 mils for each coat (except 3.0 mils dry for zinc-rich coating). Use painting methods which shall result in full coverage of joints, corners, edges and exposed surfaces.
- B. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
1. ASTM A 123 for galvanizing steel and iron products.
  2. ASTM A 153 for galvanizing steel and iron hardware.
- C. Corrosion Protection: Coat concealed surfaces in contact with concrete, masonry, wood, or dissimilar metals, in exterior work and work to be built into exterior and below grade walls and decks, with a heavy coat of bituminous paint. Do not extend coating onto exposed surfaces.
1. Do not prime surfaces in direct contact bond (embedded) with concrete or where field welding is required.
- D. Contractor: Paint shop primed items and galvanized items as specified in Section 09 90 00 – Painting.

**PART 3 - EXECUTION**

**3.1 PREPARATION**

- A. Clean and strip site painted steel items to bare metal where site welding is indicated.
- B. Make provision for erection loads with temporary bracing. Keep work in alignment.
- C. Supply items to be cast into concrete or embedded in masonry with setting templates, to appropriate crafts.

**3.2 FABRICATION**

- A. General:
1. Verify dimensions on site prior to shop fabrication.
  2. Fabricate items with joints tightly fitted and secured.
  3. Fit and shop assemble in largest practical sections, for delivery to site.
  4. Make exposed joints butt tight, flush, and hairline.
  5. Supply components for anchorage of metal fabrications. Fabricate anchorage and related components of same material and finish as metal fabrication, except where specifically noted otherwise.
  6. To the greatest extent possible, structural steel members shall be fabricated in the shop. Shop fabrication shall be planned and executed to minimize the need

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for field welding and to allow for field bolting of connections.

7. Use materials of the size and thicknesses shown or, if not shown, of the required size and thickness to produce adequate strength and durability in the finished product for the intended use. Work to the dimensions shown or accepted on Shop Drawings, using proven details of fabrication and support.
8. Form exposed Work true to line and level with accurate angles and surfaces and straight, sharp edges.
9. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
10. Form bent metal corners to the smallest radius possible without causing grain separation or otherwise impairing the Work.
11. Weld corners and seams continuously along entire line of contact to comply with the following:
  - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - b. Obtain fusion without undercut or overlap.
  - c. Remove welding flux immediately.
  - d. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
12. Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners. Only use exposed fasteners if indicated and of the type shown or, if not shown, use Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous. Make up threaded connections tight so that threads are entirely concealed.
13. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices and fasteners to secure metal fabrications rigidly in place and to support indicated loads.
14. Cut, reinforce, drill and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
15. Remove sharp or rough areas on exposed traffic surfaces.
16. Tube sections (HHS sections) and pipes shall be fabricated such that seams shall not be exposed to view in the final installation.
17. At exposed connections, pipe joints, closure plates, architectural/decorative brackets and features, etc., provide continuous monolithic appearance weld. Grind elements smooth for proper appearance and finish. Ease exposed edges to small uniform radius.
18. Provide weep holes or another means to drain entrapped water in hollow sections that are exposed to exterior or to moisture from condensation or other sources.

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19. Fabricate joints exposed to weather in a manner to exclude water or provide weep holes where water may accumulate.
- B. Railings and Guardrails:
1. Cope intersections of rails and posts, weld joints and grind smooth. Butt weld end-to-end joints of railings or use welding connectors. Handrails to be continuous, uniform and monolithic meeting ADA/IAC requirements.
  2. Weld corners and seams continuously and in accordance with the recommendations of AWS. Grind exposed welds smooth and flush, to match and blend with adjoining surfaces.
  3. Form exposed connections with hairline joints which are flush and smooth, using concealed fasteners. Only use exposed fasteners if indicated and of the type shown or, if not shown, use Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous. Make up threaded connections tight so that threads are entirely concealed.
  4. Provide for anchorage coordinated with the supporting structure. Fabricate and space anchoring devices as shown and as required to provide adequate support.
  5. Provide brackets, flanges and anchors for railing posts and for handrail supports.
  6. Where indicated, provide toe boards at railings around openings and at the edge of open-sided floors and platforms. Fabricate to dimensions and details indicated, or if not indicated, use 4 inches high x 5/16 inch steel plate welded to, and centered between, each railing post.
  7. Galvanize after fabrication at exterior locations and as indicated.
- C. Rough Hardware:
1. Furnish bent or, otherwise, custom-fabricated bolts, plates, anchors, hangers, dowels and other miscellaneous steel and iron shapes.
  2. Manufacture or fabricate items of sizes, shapes and dimensions required. Furnish malleable iron washers for heads and nuts which bear on wood structural connections; elsewhere, furnish steel washers.

### 3.3 WELDING

- A. Surfaces to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material, except that mill scale which withstands vigorous wire brushing may remain. A light film of linseed oil may be disregarded. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done with mechanically guided torch.
- B. Abutting parts to be welded shall be carefully aligned. Misalignments greater than 1/8 inch shall be corrected and, in making the correction, the parts shall not be drawn into a sharper slope than two degrees (7/16 inch in 12 inches).
- C. No welding shall be done when the temperature of the base metal is lower than 0° F. At temperature between 22° F. and 0° F., the surface of areas within three inches of the point where a weld is to be started shall be heated to a temperature at least warm to the hand before welding is started.
- D. The welding technique, the appearance and quality of welds made and the methods used

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in correcting defective work shall conform to the "Code for Arc and Gas Welding in Building Construction" of the American Welding Society, Section 4 - Workmanship. Field welds shall meet the same appearance criteria as shop fabricated welds.

- E. Backing strips may be removed by means of gas cutting, after welding is completed, provided no injury is done to the base and weld metal and the weld surface is left flush or slightly convex, with full throat thickness.

### **3.4 INSTALLATION - GENERAL**

- A. Install items plumb and level, accurately fitted, free from distortion or defects.
- B. Perform field welding in accordance with AWS D1.1. Field welds shall meet the same appearance criteria as shop fabricated welds.
- C. After installation, touch-up field welds, scratched or damaged surfaces with proper preparatory work and primer following the specified shop primer criteria herein. Coordinate with the specified finish coats to assure compatibility.

### **3.5 INSTALLATION – RAILINGS AND GUARDRAILS**

- A. Install items plumb and level, accurately fitted, free from distortion or defects.
- B. Adjust railings prior to securing in place to ensure proper matching at abutting joints and correct alignment throughout their length. Plumb posts in each direction. Securely anchor posts and railings to building construction as follows:
  - 1. Anchor posts and rail ends to steel by welding. At metal stairs coordinate with metal stair fabrication and erection requirements.
  - 2. For concrete and solid masonry anchorage, use non-corrosive drilled expansion anchors.
  - 3. For hollow masonry and stud partition anchorage, use non-corrosive toggle bolts having square heads unless noted otherwise.
  - 4. For solid wood anchorage, use non-corrosive lag screws.
- C. Posts to be embedded in slabs, core drill holes in concrete not less than 1" greater than the outside diameter of post. Clean holes of loose material, insert posts, and fill the space between post and concrete with non-shrink, nonferrous epoxy grout flush with adjacent surfaces.
- D. Anchor rail ends into concrete and masonry with round flanges welded to rail ends and anchored into the wall construction with expansion shields and bolts unless indicated otherwise.
- E. Secure handrails to walls with wall brackets and end fittings. Locate brackets as indicated or, if not indicated, at not more than 5'-0" o.c. Provide flush-type wall return fittings with the same projection as that specified for wall brackets. Secure wall brackets and wall return fittings to building construction with hanger bolts and expansion shields into solid partition construction.
- F. Handrails to be continuous, uniform and monolithic without sharp edges or visible joints, meeting ADA/IAC requirements.

### **3.6 INSTALLATION – WALL MOUNTED LADDERS**

- A. Install items plumb and level, accurately fitted, free from distortion or defects.



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- B. Provide hangers, struts, appurtenances and fasteners required for secure installation.
- C. Secure wall brackets and wall return fittings to building construction as follows:
  - 1. For concrete and solid masonry anchorage, use non-corrosive drilled expansion anchors.
  - 2. For hollow masonry and stud partition anchorage, use non-corrosive toggle bolts having square heads unless noted otherwise.
  - 3. For solid wood anchorage, use non-corrosive lag screws.
- D. Coordinate requirements for interior unit with roof hatch assembly and associated ladder safety post for a complete and proper functional installation.
- E. Install security access panel on indicated ladders.

**3.7 TRIMMING AND SEALING STAINLESS STEEL FABRICATIONS**

- A. Any space between fabrications and walls, ceilings, floors and adjoining units, not portable, shall be completely sealed against entrance of food particles or vermin by means of trim strips, appropriately welded and finished, or commercial sealant, suitable to the nature of the equipment.
- B. Sealant, when not exposed to extreme heat, shall be Food Grade Silicone Sealant in appropriate color. Sealant shall not span more than 1/4" and shall be finished smooth and be easily cleanable.
- C. Ends of hollow sections shall be closed.

**END OF SECTION 05 5000**



**SECTION 05 5100  
METAL STAIRS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of work shown on the drawings and/or specified in this section.

**1.2 SUBMITTALS**

- A. Shop Drawings: Shop drawings showing size, construction, arrangement and installation details.

**1.3 QUALITY ASSURANCE**

- A. Comply with "Recommended Voluntary Minimum Standards for Fixed Stairs" in National Association of Architectural Metal Manufacturers (NAAMM) "Metal Stair Manual" except where more stringent requirements are required.
- B. Guardrails and handrails at a minimum shall be capable of sustaining 200 pound concentrated load in any direction, a vertical load of 100 plf, and a horizontal thrust of 50 plf acting outwardly at the top of the rail.
  - 1. Guardrails and handrails must be designed to meet at a minimum the design loads, and applicable codes and standards requirements.

**1.4 WORK DESCRIBED ELSEWHERE**

- A. Metal stair work, in addition to the requirements of this Section, shall be done in accordance with and meet the requirements of Section 05 12 00 - Structural Steel and 05 50 00 - Metal Fabrications in respect to design, fabrication, submittals, products, erection and shop painting.
  - 1. Refer to section 05 50 00 for guardrails, railings, handrails, and posts.

**PART 2 - PRODUCTS**

**2.1 INTERIOR STAIRS & RAILINGS**

- A. Stair system including landings and treads, shall be a concrete filled metal pan stair system, as detailed and indicated.
  - 1. Provide necessary incidental beams, bracing, and supports required for a complete and proper finished installation.
- B. Stringers shall be hot or cold rolled steel channels. Stringers shall have steel plate closers on exposed surfaces. Risers and sub-treads shall be 14 gauge metal. Platforms and landings shall be 10 gauge metal. Provide stringers along walls as indicated and additional stringers concealed within center of stair run at 5'-0" on center.
- C. Beams, carrier angles and struts shall be of sizes called for and/or required.
- D. Treads and landings shall be pan type filled with concrete as indicated. Nosings at treads and landings to be 2" vertical face type meeting ADA requirements and compatible with specified rubber treads and risers. Intermediate platforms and treads shall have tee or angle stiffeners as required.

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**PART 3 - EXECUTION**

**3.1 ERECTION**

- A. Stairs shall be securely anchored to supporting members, floors, and walls unless otherwise noted and/or detailed.
- B. Handrails, guardrails, and posts shall be anchored to stringers, pans, and walls as detailed and/or noted on the drawings. Provide metal wall brackets secured to wall construction as indicated for handrails.
- C. Install items plumb and level, accurately fitted, free from distortion or defects.
- D. Perform field welding in accordance with AWS D1.1. Field welds shall meet the same appearance criteria as shop fabricated welds.
- E. At exposed connections, architectural/decorative brackets and features, closure plates, etc., provide continuous monolithic appearance weld. Grind elements smooth for proper appearance and finish. Ease exposed edges to small uniform radius.
- F. Metal grating units to be installed meeting the requirements of National Association of Architectural Metal Manufacturers Standards.
  - 1. Weld non-removable units to supporting members or framework.
  - 2. Secure units indicated to be removable to supporting members or framework with galvanized machine screws, or manufacturer's standard saddle or clip units.
- G. After installation, touch-up field welds, scratched or damaged surfaces with proper preparatory work and primer following the specified shop primer criteria herein. Coordinate with the specified finish coats to assure compatibility.
  - 1. Galvanized steel items to be touched up with manufacturer's galvanized primer.

**END OF SECTION 05 5100**

**SECTION 06 1000  
ROUGH CARPENTRY**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of work shown on the drawings and/or specified in this section.

**1.2 REFERENCE**

- A. Framing Standard: American Forest & Paper Association's WCD 1, "Details for Conventional Wood Frame Construction".

**1.3 SUBMITTALS**

- A. Product Data
- B. Wood Treatment Data:
  - 1. Rot-Resistant Treatment: Submit Certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained and conformance with applicable standards.
  - 2. Fire-Retardant Treatment: Submit Certification by treating plant that treatment material complies with specified standard and other requirements.
    - a. Include certified classification from manufacturer's testing agency, either Underwriters Laboratories, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction, including meeting or exceeding the requirements of the specified rated assembly testing agency.
- C. Certification: Modification of Engineered Wood Product (LVL) components.

**1.4 PRODUCT HANDLING**

- A. Keep materials under cover and dry. Protect against exposure to weather and contact with damp or wet surfaces. Provide for air circulation within and around stacks and under temporary coverings including polyethylene and similar material.

**1.5 PROJECT CONDITIONS**

- A. Fit carpentry work to other work; scribe and cope as required for accurate fit. Correlate location of nailers and similar supports to allow attachment of other work.

**PART 2 - PRODUCTS**

**2.1 LUMBER**

- A. Rough lumber for plates, blocking, nailers, etc., without large knots or splits shall be a minimum of No. 2 & better Doug-Fir Larch, Southern Yellow Pine, or SPF's (Spruce-Pine-Fir South) with fiber stress (fb) = 1,100 psi minimum. Provide continuous and intermediate lengths as required.
  - 1. Utility, standard, stud and No. 3 grade of any lumber species are not permitted.

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2. Rough lumber in contact with concrete or earth, to be pressure treated for rot resistance as specified herein.

## **2.2 PLYWOOD**

- A. Plywood floor decking to be 3/4" nominal thickness, T & G edge, Group 1 species.
  1. 23/32 PERF CAT APA Rated STURD-I-FLOOR 16" oc Exposure 1.
- B. Plywood wall sheathing to be 5/8" nominal thickness, square edge, Group 1 species.
  1. 19/32 PERF CAT APA Rated Sheathing 24/16 Exposure 1.
- C. Plywood roof sheathing to be 5/8" nominal thickness, square edge, Group 1 species.
  1. 19/32 PERF CAT APA Rated Sheathing 40/20 Exposure 1.
- D. Plywood as indicated for roofing nailer assemblies, blocking, etc. to be 3/4" thickness, square edge, Group 1 species.
  1. 3/4 PERF CAT APA C-C Exposure 1.
- E. Plywood as indicated for use at stainless steel countertops and sills to be 3/4" nominal thickness, square edge, Group 1 species.
  1. 23/32 PERF CAT APA C-C Plugged Exterior.
- F. Miscellaneous plywood indicated within walls and/or roof areas to match the specified plywood wall or roof sheathing for the application condition.
- G. Interior wall sheathing, to receive surface applied FRP panels, to be 1/2" nominal thickness sanded plywood panels, square edge, Group 1 species.
  1. 15/32 PERF CAT APA A-D Exposure 1.
- H. Plywood as indicated for use as an interior exposed mounting board for low voltage equipment such as FACP, TTB, etc. to be at a minimum 5/8" nominal thickness, square edge, Group 1 species.
  1. 19/32 PERF CAT APA A-D Exposure 1
- I. Miscellaneous plywood for temporary use such as enclosures and protection boards to be at a minimum 5/8" thickness, square edge, Group 1 species.
  1. 19/32 PERF CAT APA C-C Exposure 1.
  2. 19/32 PERF CAT APA C-C Plugged Exterior; provide if subject to prolonged exposure to weather affecting the weather tightness of the installation.

## **2.3 TREATED WOOD PRODUCTS**

- A. Meet requirements specified in 2.01 for Lumber and 2.02 Plywood.
- B. Rot Resistant Treated: Rough lumber indicated to be treated, in contact with concrete, gravel, earth, and where indicated, exposed to all weather cycles, to be pressure treated for rot resistance, AWPAC Category UC4a for exterior items with ground contact, Kiln dried after treatment to a maximum moisture content of 19 percent. Products containing arsenic, chromium, or inorganic boron are not acceptable. Warped material is not acceptable.
  1. Exterior construction, exposed to elements

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- C. Rot Resistant Treated: Rough lumber indicated to be treated, above grade, protected from weather, to be pressure treated for rot resistance, AWPA Category UC2 for interior items without ground contact, Kiln dried after treatment to a maximum moisture content of 19 percent. Products containing arsenic, chromium, or inorganic boron are not acceptable. Warped material is not acceptable.
  - 1. Interior construction, concealed
- D. Fire Retardant Treated (FRT): Rough lumber indicated to be fire-retardant-treated (FRT), to be pressure impregnated with fire-retardant chemicals, AWPA Category UCFA for interior items without ground contact and protected from exterior exposure; identify lumber with appropriate classification marking of Underwriters Laboratories, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction. Maximum moisture content of 19 percent. Warped material is not acceptable.
  - 1. Interior construction, concealed
- E. Fire Retardant Treated (FRT) Plywood Roof Sheathing: Plywood roof sheathing indicated to be fire-retardant-treated, to be 5/8" nominal thickness, square edge, Group 1 species, fire-retardant-treated (FRT) plywood pressure impregnated with fire-retardant chemicals in accordance with AWPA C27, Category UCFA for interior items without ground contact and protected from exterior exposure.
  - 1. FRT plywood sheathing must meet the performance category requirements and load capacities of the specified plywood roof sheathing.
  - 2. Flame spread rating of 25 or less in accordance with ASTM E 84, Class I.
  - 3. Identify with appropriate classification marking of Underwriters Laboratories, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.

**2.4 FLEXIBLE WALL FLASHING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Grace Construction Products, Perm-A-Barrier Wall Flashing
  - 2. W.R. Meadows, Inc., Air-Shield Thru-Wall Flashing
- B. Flexible wall flashing to be 40 mil. self-adhesive membrane, rubberized asphalt, self-healing, integrally bonded to cross-laminated, high-density polyethylene film. Membrane shall be interleaved with disposable coated release paper until installed.
- C. Primer for Flexible Membrane Wall Flashing:
  - 1. Grace Construction Products, Perm-A-Barrier WB Primer
  - 2. W.R. Meadows, Inc., MEL-Prime W/B

**2.5 ENGINEERED WOOD PRODUCTS - LAMINATED VENEER LUMBER (LVL)**

- A. Laminated Veneer Lumber of series called for on the drawings, shall be structural composite lumber made from wood veneers with grain primarily parallel to member lengths, evaluated and monitored according to ASTM D 5456 and manufactured with an exterior-type adhesive complying with ASTM D 2559.
- B. Subject to compliance with requirements, provide products by one of the following.
  - 1. Trusjoist MacMillan

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2. Alpine Engineered Products, Inc.
3. Gang-Nail Systems, Inc.
- C. Include extended ends and accessories for the complete and proper installation.
- D. Minimum modulus of elasticity shall be 2,000,000 psi.

**2.6 MISCELLANEOUS MATERIAL METAL FRAMING ANCHORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by:
  1. Simpson Strong-Tie Co., Inc.
- B. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those indicated. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.
  1. Provide proper number and size fasteners to comply with required loads.
- C. Hot-Dip, Heavy-Galvanized Steel Sheet: ASTM A 653/A653M; Structural steel (SS), high-strength low-alloy steel Type A (HSLAS Type A), or high-strength low-alloy steel Type B (HSLAS Type B); G185 (Z550) coating designation; and not less than 0.036 inch (0.9 mm) thick.
  1. Provide stainless steel framing anchors where use with fire retardant treated (FRT) lumber.

**2.7 MISCELLANEOUS MATERIALS**

- A. Rough hardware. Bolts, screws, nails, expansion anchors, hangers, clips, etc., necessary for connection of carpentry, framing, and lumber members shall be of proper size, configuration and strength and shall be hot dipped heavy galvanized.
  1. Rough hardware for use with treated members shall be stainless steel.
  2. Rough hardware for use with fire retardant treated (FRT) plywood shall be stainless steel unless FRT panel manufacturer allows hot dipped galvanized for the intended application.
  3. Rough hardware for exterior gypsum wall sheathing to be hot dipped galvanized drilled fasteners of the proper type for each condition meeting sheathing manufacturers requirements.
- B. Anchor Bolts: L-shaped steel bolts complying with ASTM A 307, Grade A (ASTM A 325M, Property Class 4.6); with comparable hex nuts and, flat washers; hot-dip galvanized to comply with ASTM A 153/A 153M, Class C; of dimensions indicated.
  1. Anchor bolts for use with treated members shall be stainless steel.
- C. Plywood roof sheathing metal H-clips shall be prefabricated units of the proper size, configuration and strength, and shall be 20 gauge minimum hot dipped galvanized steel. Clips must be the proper type for the thickness of the panels being supported, and allow for APA recommended 1/8" gap between panels.
  1. Clips for use with fire retardant treated (FRT) plywood shall be stainless steel unless FRT panel manufacturer allows hot dipped galvanized for the intended application.
- D. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.



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- E. Sill-Sealer Gaskets: ASTM D 1056-91, high density closed-cell neoprene foam strip sill sealer with pressure sensitive adhesive on one side, 1/4 inch thick, match width of sill plate members.
  - 1. Hohmann & Barnard, Inc., Neoprene Sill Sealer

**PART 3 - EXECUTION**

**3.1 GENERAL**

- A. Do not use lumber of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned or too small to fabricate the Work with a minimum of joints or the optimum jointing arrangement.
- B. Treated lumber and wood products, apply minimum 1/16" coating of bituminous paint to the contact surface of steel, galvanized steel, and aluminum to ensure separation from contact with the treated products.
- C. Frame and bolt framing as detailed or as required in straight lines, securely anchored.
- D. Plates and sills resting on masonry or steel shall be secured with bolts of required size and length with suitable washers and nuts spaced not more than 4'-0" o.c. or as detailed.
- E. Install grounds for application of wood trim, etc., where required and of proper thickness and securely fastened.
- F. Frame soffits, install furring, blocking, etc., as shown or required.
- G. Fit carpentry work to other Work. Scribe and cope as required for accurate fit.
- H. Set carpentry work accurately to required levels and lines with members plumb and true.
- I. Securely attach carpentry work to substrates by anchoring and fastening as shown and as required by recognized standards.
- J. Provide washers under bolt heads and nuts in contact with wood.
- K. Select fasteners of size that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting of wood; predrill as required.
- L. Do not drive threaded friction-type fasteners; turn into place. Tighten bolts and lag screws at installation and retighten as required for tight connections prior to closing in or at completion of Work.
- M. Set wood framing accurately to required lines and levels. Provide framing members of sizes and on spacings shown, and frame openings as shown or, if not shown, comply with the recommendations of the NFPA (National Forest Products Association). Cut, join and tightly fit framing around other Work. Do not splice structural members between supports unless otherwise detailed.
- N. Anchor and nail as shown or, if not shown, to comply with the Recommended Nailing Schedule and other recommendations of NFPA.
- O. Grounds, Nailers and Blocking:
  - 1. Provide wherever shown and where required for screeding or attachment of other Work. Form to shapes and cut as required for true line and level of Work to be attached or screeded.

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2. Provide solid wood blocking built into gypsum board partitions and walls where shelving, cabinets, toilet partitions, accessories and similar are secured.
  3. Coordinate location with other Work. Refer to Shop Drawings of such Work, if any.
  4. Attach to substrates securely with anchor bolts or other attachment devices as shown and as required to support applied loading.
  5. Countersink bolts and nuts flush with surfaces, unless otherwise indicated.
  6. Build into masonry as Work progresses, cutting to fit masonry unit size involved.
  7. Anchor to formwork before concrete placement.
- P. Temporary closers shall be of substantial construction with appropriate security measures provided as required.

### **3.2 TREATED LUMBER**

- A. Install rot resistant treated lumber where indicated and required including necessary incidentals, components, etc.
1. Rough hardware for use with treated members shall be stainless steel.
- B. Install fire retardant treated (FRT) lumber where indicated and required including necessary incidentals, components, etc. meeting the requirements of the specified assembly testing agency, and the authority having jurisdiction to provide at a minimum the required fire rated assembly.
1. Rough hardware for use with treated members shall be stainless steel.

### **3.3 STRUCTURAL FRAMING**

- A. Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.
- B. Sill plates to be continuous, in longest lengths possible. At exterior walls set on concrete foundations with continuous sill-sealer neoprene gaskets of width matching sill plate, and securely anchor to foundation wall with cast-in anchor bolts as indicated. At existing concrete foundation walls and at interior wall locations securely anchor to concrete with drilled epoxy expansion anchors. Sill-sealer gaskets are not required at interior walls.
- C. Stud System Erection. Attach sill plates at floor with suitable fasteners located 2" from each end and spaced 16" o.c. engaging floor joists. Position studs vertically, engaging floor and ceiling plates and spaced 16" o.c. Studs shall run full height from sill plates at floor to height as indicated. Place studs in direct contact with door frame jambs, abutting partitions and partition corners.
- D. Anchor studs for shelf-walls, counter, vanity, and those adjacent to door frames, partition intersections, and corners to ceiling and floor sill plates with mechanical fasteners. Securely anchor studs to jamb and head anchor clips of door frames by screw attachment.
- E. Framing components shall be cut squarely for attachment to perpendicular members, or as required for an angular fit against abutting members. Members shall be held positively in place until properly fastened.
- F. Construct corners using minimum 3 studs, double stud at wall opening, door and windows jambs.

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- G. Erect studs 1 piece full length; splicing of studs not permitted.
- H. Provide necessary stud bracing, etc. as detailed and/or required to support design and anticipated loads.
- I. Install intermediate studs above and below openings to match wall stud spacing.
- J. Install framing between studs for attachment of mechanical and electrical items, and to prevent stud rotation.
- K. Provide substantial intermediate wood blocking properly anchored to studs for secure attachment of wall mounted items including but not limited to door stops, toilet accessories, wall mounted equipment, casework, etc.
- L. Install Engineered Wood Products per manufacturers requirements. Modifications to these products require review and approval by the manufacturer.

**3.4 GENERAL DECKING AND SHEATHING INSTALLATION**

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate and supports by fastening as indicated, complying with the more stringent of the following:
  - 1. NES NER-272 for power-driven fasteners
  - 2. IBC 2015 Table 2304.10 Fastening Schedule

**3.5 FLOOR DECKING**

- A. Plywood floor decking to be installed continuous over two or more spans, strength axis perpendicular to supports. Ends shall be centered over supports. Secure to supports with continuous bead of adhesive, and with mechanical fasteners spaced at a minimum of 6" o.c. at panel edges and 12" o.c. at intermediate supports. Top layer of decking to be adhered over base layer decking with joints staggered from base layer and secured in the same manner.
  - 1. Wood framing, secure with non-corrosive ring or screw shank 8d nails.
  - 2. Metal framing, secure with non-corrosive hardened screw shank or self-tapping fasteners of the proper size and type. Pneumatically-driven steel pins are not acceptable.

**3.6 WALL SHEATHING**

- A. Plywood wall sheathing to be installed continuous over two or more spans, strength axis perpendicular to supports, with ends staggered between panels and centered over supports. Secure to supports with continuous bead of adhesive, and with mechanical fasteners spaced at a minimum of 6" o.c. at panel edges and 12" o.c. at intermediate supports.
  - 1. Wood framing, secure with non-corrosive deformed shank 8d nails.
  - 2. Metal framing, secure with non-corrosive hardened screw shank or self-tapping fasteners of the proper size and type. Pneumatically-driven steel pins are not acceptable.

### **3.7 FLEXIBLE WALL FLASHING**

- A. Install membrane flashing, and auxiliary materials according to manufacturer's written instructions to form a seal with adjacent construction and maintain a weathertight barrier.
- B. Apply primer to substrates to receive membrane flashing at required rate and allow to dry. Limit priming to areas that will be covered in same day. Re-prime areas exposed for more than 24 hours.
  - 1. Prime glass-fiber-surfaced gypsum sheathing and/or roof underlayment board not covered with an air membrane material with number of prime coats needed to achieve required bond, with adequate drying time between coats.
- C. Fill gaps in perimeter framed wall opening surfaces and miscellaneous sheathing penetrations with foam insulation sealant prior to flashing installation.
- D. Connect and seal membrane flashing continuously to roofing membrane air barrier.
- E. Repair punctures, voids, and deficient lapped seams in membrane per manufacturers requirements. Slit and flatten fish-mouths and blisters. Patch with membrane extending 6 inches beyond repaired areas.

### **3.8 ROOF SHEATHING**

- A. Plywood roof sheathing to be installed continuous over two or more spans, strength axis perpendicular to supports, with ends centered over supports. Space nails no less than 6" o.c. at panel edges and 12" o.c. at intermediate supports using non-corrosive deformed shank 8d nails.
  - 1. Provide proper metal H-clips between adjacent panels and at any unavoidable unsupported edges. Clip spacing at a minimum to be one per span of supporting framing member and as required by the loads.
  - 2. Roof sheathing to be covered and protected from moisture with the specified roofing felts as appropriate sized areas are completed and in a manner to avoid interference between tradesmen.
- B. Fire retardant treated (FRT) plywood roof sheathing panels to be kept dry and protected from moisture, wetting, and condensation during shipping, storage, and installation. Install sheathing continuous over two or more spans, strength axis perpendicular to supports, with ends centered over supports. Space nails no less than 6" o.c. at panel edges and 12" o.c. at intermediate supports using stainless steel deformed shank 8d nails.
  - 1. Install FRT panels meeting the requirements of the specified assembly testing agency, and the authority having jurisdiction to provide at a minimum the required fire rated assembly.
  - 2. Provide proper metal H-clips between adjacent panels and at any unavoidable unsupported edges. Clip spacing at a minimum to be one per span of supporting framing member and as required by the loads.
  - 3. FRT roof sheathing to be covered and protected from moisture with the specified roofing felts as appropriate sized areas are completed and in a manner to avoid interference between tradesmen.

### **3.9 ROOF NAILERS AND EDGE ASSEMBLIES**

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- A. Roofing nailers and blocking, to be installed as indicated and called for in specified roofing sections.
  - 1. Install grounds for application of wood roofing nailers and blocking, etc., where required and of proper thickness and securely fastened.
  - 2. Fabricate roof edge assemblies with nailers, plywood, blocking, etc. as indicated to provide a secure, stable substrate properly anchored to wall construction to meet applicable codes and standards, and meet roofing system requirements.
    - a. At curved wall locations provide additional layers of specified plywood cut to indicated radius in lieu of multiple 2x nailers. Bottom exterior and interior edges of assembly to be 2x3 nailers cut to meet indicated radius from 2x10 specified material in longest lengths possible to minimize joints.

**END OF SECTION 06 1000**



**SECTION 07 4213**  
**FORMED METAL WALL PANELS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified under this section.

**1.2 SCOPE OF WORK**

- A. Work under this section shall include, but not necessarily be limited to the following:
  - 1. Siding.
  - 2. Metal Furring.
  - 3. Miscellaneous fascias, flashing, closure strips, corners, etc.
  - 4. Fasteners.

**1.3 SUBMITTALS**

- A. Shop drawings.
- B. Samples of finish colors on metal.

**1.4 WARRANTY**

- A. Furnish a written 20 year non-prorated manufacturer's warranty on finish.

**PART 2 - PRODUCTS**

**2.1 METAL SIDING PANELS**

- A. Siding panels shall be 1-1/2" x 12" wide flush faced preformed panels with grooves.
  - 1. Centria, CFP-111-2
  - 2. Morin Corp., Mor-Wal A-12
  - 3. Vicwest Steel, Select Series-12 (R-2)-12
  - 4. Reynolds Metals, comparable to 1. above.
- B. Material shall be 22-gauge G-90 galvanized steel.
- C. Panels to be continuous in length without horizontal seams.
- D. Finish shall be two coat "Kynar 500" system with 0.9 mil. min. dry film thickness. Color as selected by Architect from manufacturer's full range of colors regardless of quantity.

**2.2 METAL FURRING**

- A. Provide 7/8" galvanized 20 ga. metal furring for securing siding to walls and framing as indicated on drawings.

**2.3 FASCIAS, FLASHINGS, CLOSURES, TRIM**

- A. Associated fascias, flashings, closures, trim, etc. shall be of the same material and finish as siding.

**2.4 FASTENERS**

RPS 2251; IFB 22-32  
KED 21-105

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- A. Fasteners shall be concealed type typical for panels. Fasteners for end laps to be rubber gasketed exposed non-corrosive fasteners with same finish as siding.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Material shall be applied to metal furring with concealed fasteners and in accordance with manufacturer's recommendations. End lap seam trim shall be fastened with exposed fasteners and in accordance with manufacturer's recommendations. Panel joints and end lap seams shall have sealant or continuous gaskets applied per manufacturer's recommendations. Sealant type to be per manufacturer's recommendations.
- B. Fascia shall be applied to wood backing as detailed and in accordance with manufacturer's recommendations with continuous 24 ga. galvanized metal cleats.
- C. Provide concealed 3" closure at section joints of same material, caulked in to provide a weathertight condition and allow for expansion. Provide 3/8" joint between sections centered on closure. Rake ends to be drain lapped 3" minimum.

**END OF SECTION 07 4213**



**SECTION 07 5424**  
**TPO MEMBRANE ROOFING**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified under this section.
- B. Be responsible for the condition of the building and site, and provide necessary provisions to protect the building, adjacent work and contents, and site. Replace/restore items and surfaces damaged in carrying out the work.
- C. It is the intent of this specification to assure weathertight and watertight conditions, during and after completion of the Work. The Contractor performing the work is expected to advise the Architect of any unusual or unforeseen conditions arising during the project.

**1.2 SCOPE OF WORK**

- A. Demolition
- B. Thermoplastic Polyolefin (TPO) Single-Ply Roof System
  - 1. Furnish and install a TPO Single-Ply Roofing System, Class "A" rated, including incidental and accessory items, including, but not limited to the following:
    - a. Vapor Barrier
    - b. Insulation
    - c. Fasteners
    - d. Adhesives
    - e. Roofing Membrane
    - f. Flashings and Metal Edge
    - g. Expansion Joint
    - h. Accessories
    - i. Slip Sheet
    - j. Wood Nailers
    - k. Warranty

**1.3 SUBMITTALS**

- A. Shop Drawings: Roof Plan with details to indicate roof edge, flashing, penetrations, and miscellaneous items.
- B. Product Data:
  - 1. Roofing membrane, flashing, adhesive, accessories.

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2. Vapor Barrier
  3. Protective Membrane
  4. Expansion Joint
  5. Walkway Pads
  6. Slip Sheet
  7. Fasteners
- C. Roofing contractor qualifications.
- D. Roof system manufacturers approval to proceed with installation.
- E. Roof system manufacturers periodic inspection and mechanical fastener pull out test results as they occur.
- F. Written warranty.

**1.4 QUALITY ASSURANCE**

- A. Roofing Contractor must have a minimum of ten (10) years experience installing TPO Single-Ply Roofing Systems specified. Roofing Contractor must be roofing system manufacturers' current approved premium installers in good standing with corporate office located within 50-mile radius of Rockford Public Schools. Owner reserves the right to reject any contractor with past history with the District of: failure to perform the work meeting specifications; excessive call backs for leaks; ongoing issues not corrected; etc.
- B. Pre-Roofing Conference: A pre-roofing conference shall be held at the project site in advance of the time scheduled for roofing work. The purpose of this conference is to review requirements for the work and conditions which could possibly interfere with successful performance of the work. This conference shall review deck surfaces, roof insulation, roofing, flashing, and any other item related to the roof system. A record of all decisions and agreements made at this meeting, as well as a list of attendees, shall be submitted to the Architect in writing for record.
- C. Roofing system manufacturer: Roofing system mechanical fastener pull out tests on components including but not limited to roof system edge securement, nailers, blocking, underlayment board, insulation, etc. to be performed by the roofing system manufacturer, and meet the requirements of the specified full system warranty.

**1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING**

- A. Deliver roofing materials in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storage.
1. Materials shall be delivered to the site in an undamaged and dry condition.
  2. Material received which is not dry or is otherwise damaged shall be rejected.
- B. Storage under polyethylene or similar non-breathing film stock shall not be permitted, and materials are never to be in contact with the ground.
1. Proper storage on or off the site shall be the responsibility of the contractor.

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- C. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer.
- D. Handle and store roofing materials and place equipment in a manner to avoid permanent deflection of deck.

**1.6 WARRANTY**

- A. The Contractor shall furnish to the Owner, the Manufacturer's Full System No Dollar Limit Warranty of watertightness. This warranty shall be fully paid for by the Roofing Contractor.
  - 1. Warranty Period: 20 years from date of Substantial Completion.
  - 2. Warranty shall provide at a minimum, manufacturer's wind speed coverage of maximum 72 mph, 3-second peak gusts, measured at 10 meters (33ft) above ground level.
- B. This Warranty shall cover both labor and materials necessary to effect watertightness, including that required to repair conditions caused by structural movement or standing water on the roof membrane, without limit as to amount required to effect repairs.

**PART 2 - PART 2 - PRODUCTS**

**2.1 ROOFING MEMBRANE**

- A. Thermoplastic polyolefin (TPO) sheet, internally fabric reinforced, meet or exceed ASTM D6878 Requirements, with an initial solar reflectance index (SRI) of not less than 99 and three year aged SRI of not less than 85.
  - 1. Thickness: 60 mils
  - 2. Exposed Face Color: Gray
  - 3. System Type: Fully Adhered
- B. Subject to compliance with requirements, provide products by one of the following:
  - 1. Firestone Building Products, Ultraply Platinum.
  - 2. Carlisle Corp., Sure-Weld EXTRA.
  - 3. Johns-Manville, TPO ST8RA-S.
- C. Provide necessary flashing and accessories as required or recommended by roofing system manufacturer. Flashing shall be 60 mil uncured TPO.
- D. Provide materials, incidentals, and installation procedures required for the manufacturer's specified full system warranty.

**2.2 VAPOR BARRIER**

- A. Vapor Barrier to be roofing system manufacturers self-adhering, polypropylene reinforced rubberized asphalt air and vapor barrier membrane system, meet or exceed ASTM D1970, E96 and E2178 requirements.
  - 1. Firestone Building Products, V- Force
  - 2. Carlisle Corp., VapAir Seal 725TR

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3. Johns-Manville, JM Vapor Barrier SA

**2.3 ACCESSORIES**

- A. Provide manufacturers accessories as necessary and required to provide a full systems approach, including but not limited to:
  - 1. Pre-molded accessories such as inside corners, outside corners, curb wrap corners, pipe flashing, pipe seals, sealant pockets, etc.
  - 2. Adhesives, sealants, pre-molded and field fabricated flashings, fasteners, and other related components manufactured or recommended by the selected roofing system manufacturer.

**2.4 WALKWAY PADS**

- A. Manufacturers factory formed, non-porous, heavy duty, slip resistant, surface textured TPO walkway pads, heat weldable, 5/32" min. thickness; standard sizes 24" x 24" or 30" x 30" as indicated.
  - 1. Manufacturers roll type system meeting specified criteria is acceptable.

**2.5 NAILERS**

- A. Wood nailers and nailer assemblies shall be installed where required and indicated. Height of nailers and assemblies shall be matched to that of the insulation being used and as indicated.
- B. Nailers and nailer assemblies are as specified in Section 061050 – Miscellaneous Rough Carpentry.

**PART 3 - EXECUTION**

**3.1 GENERAL REROOF**

- A. roofing, flashings, metal fascia, metal coping, etc. and rigid insulation down to existing roof deck.
  - 1. Remove an area no larger than can be re-roofed in one day.
- B. Repair existing roof deck and nailers deteriorated or damaged during tear off.
- C. Remove existing soil stack leads and replace with new 4# leads.
- D. Remove existing roof drain leads and provide new 4' x 4' - 4# leads at each drain.
- E. Remove existing dome strainers, clamping rings, lugs, and clamping devices at roof heads and clean prior to installation of new roofing system. After new roof system is installed clean and rod roof drain lines serving reroof area for proper operation from roof to point of discharge onto grade or into storm sewer to provide a complete and proper functioning system to insure positive drainage. Provide new metal dome strainers, clamping rings, lugs, etc. at existing roof drain locations to provide a complete and proper functioning system to insure positive drainage. Provide necessary components and incidentals to provide a complete and proper weathertight installation.
- F. Curb flashing at existing exhaust fans, mechanical units, etc. shall be removed to allow proper flashing installation and then replaced on curbs in proper operating condition and in a manner insuring weather tight installation as recommended by manufacturer.

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1. Raise mechanical items, roof hatches, etc. and extend curbs as required to provide 8" minimum height above roof surface to top of exposed flashing membrane. Disconnect and extend services by licensed tradesman as required to provide a complete and proper operating condition.
  2. Secure flashing and install new metal counterflashing prior to re-installation of unit.
  3. Perimeter nailers must be added to match elevation of new roof insulation.
- G. Remove abandoned mechanical items, roof curbs, piping, conduit, etc. Infill roof deck openings as required to provide a stable, secure, load bearing structural roof deck surface to receive the new roof system as indicated on the Drawings.
1. At mechanical items to be removed with associated roof curb to remain abandoned in place:
    - a. After removal of existing mechanical equipment, conduit, piping, ductwork, etc. by licensed tradesman, repair any damage to the existing roof curb to provide a stable, sound weathertight condition.
    - b. Extend top of curb as required by the new top of roof surface elevation to provide 8" minimum exposed height of vertical roof flashing after cap is set in place.
    - c. Cap top of curb with weathertight, insulated, one piece galvanized metal cap.
- H. Immediately remove debris from roof surface. Demolished roof system may not be stored on the roof surface.

### 3.2 INSPECTION

- A. Examine surfaces for inadequate anchorage, foreign material, moisture, unevenness, or other conditions which could prevent the best quality and longevity of roofing, flashing, and accessory components. Notify the architect of deficiencies.
1. Verify installation conditions as satisfactory to receive work.
  2. Verify that work of other trades penetrating roof deck or requiring workers and equipment to transverse roof deck has been approved by roofing system manufacturer, and contractor.
  3. Check projections, curbs, and deck for inadequate anchorage, foreign material, moisture, or unevenness that would prevent quality and execution of new roofing system. Determine it is free from defects, nails, and other irregularities. Decks to be dry prior to starting roof work.
  4. Do not install new roofing until unsatisfactory conditions are corrected.
  5. Beginning work constitutes acceptance of conditions by the contractor and roofing system manufacturer, and shall imply approval of deck surfaces and site conditions; and no claim in this respect will be considered valid in case of failure of the roofing components within the warranty period.

### 3.3 FIELD QUALITY CONTROL

- A. Contractor to make arrangement for the roofing system manufacturer to perform the required

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fastener pull out tests, provide initial inspection and periodic inspections of the roofing system as appropriate and as required for warranty inspections, including whenever called upon by the Architect for the duration of the installation.

1. Upon completion of the installation, final inspection shall be made by the roofing system manufacturer to ascertain that the roofing system has been installed according to the manufacturer's published specifications and details, and meets the specified full system warranty requirements. The written warranty is to be issued upon final approval of the installation.
- B. Contractor to accompany the manufacturer's technical inspector and assist with equipment and workmen if necessary to provide access to the roof.
  1. Correct defects noted during the inspections.

### **3.4 PREPARATION**

- A. Ensure that surfaces are clean and dry before starting and during performance of work.
- B. Verify that work of other contractors and subcontractors which penetrates the roof deck or requires men and equipment to traverse the roof deck has been completed.
- C. Provide written confirmation that the roof system manufacturer's fastener pull out test results and initial inspection has indicated the work can proceed meeting the requirements of the specified full system warranty.

### **3.5 GENERAL**

- A. Install Roof System following current manufacturer's written instructions, recommendations, and details. Provide materials, incidentals, and installation procedures required for the manufacturer's specified full system warranty.
  1. Install roofing system only in dry weather.
  2. Comply with manufacturer's climatic restrictions.
  3. Roofing membrane to be installed over manufacturer's slip sheet if required.
- B. Material shall be one-piece roof membrane adhered to roof insulation with roofing manufacturers low VOC bonding adhesive, formed by heat welding meeting manufacturer's requirements for the specified full system warranty. At a minimum seams shall be made by lapping the membrane a minimum of two inches (2") over itself or over flashing, making a continuous seam two inches (2") wide allowing for a minimum 1½" wide continuous weld. This seam shall then be checked for continuity and integrity, and as required for the specified full system warranty sealed with 8" wide membrane joint covers, and sealant. Seams are to be welded and sealed the same day.
  1. Follow manufacturer's requirements for seam lap direction relative to slope, which varies depending on degree of slope.
  2. Provide manufacturers additional membrane securement at areas exceeding 2" slope in 12" horizontal.
- C. Once work is started on a roof or section, it shall continue without undue delay until that section is completed before starting another. The installation of flashings shall follow application of the roofing without delay.

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- D. Nailers and nailer assemblies shall be firmly anchored to the structure, perimeter walls, etc. with non- corrosive fasteners to resist a force of 200 pounds per lineal foot in any direction. Masonry walls to have embedded anchor bolts as indicated. 2" vent spaces shall be left between lengths of nailers and assemblies.
  - 1. Anchors in double row conditions to have each row staggered equally from the other.
  - 2. Provide a minimum of 5 anchors (per row) for each 8' length of nailer and assembly, shorter sections provide a minimum of 3 anchors (per row).
- E. Install insulation as called for in Section 07200 - Insulation. Insulation to be installed over roofing system manufacturers vapor barrier using adhered methods without mechanical fasteners.
  - 1. Mechanical fastener penetrations through the vapor barrier are not acceptable.
- F. Flashing shall be installed at vertical surfaces, roof interruptions and penetrations as detailed, and in accordance with roofing membrane manufacturer's current published details consistent with job conditions. Where details appear to be in conflict with those published, then the details shall govern and control. Flashings and terminations shall be securely fastened in place to the roof deck with suitable fasteners to provide holding force of not less than two hundred (200) pounds per lineal foot in any direction for the expected life of the roof.
  - 1. Fasteners shall be installed at intervals not to exceed eight inches (8"), except where otherwise specified or recommended by the manufacturer.
- G. Water cut-offs shall be made by extending the membrane beyond the insulation and setting the end of the membrane in 4" of roofing system manufacturer's approved roofing cement overlapped to existing membrane. Temporary water cut-offs shall be removed prior to proceeding with the next work period by cutting off that portion of the membrane that has been in contact with the roofing cement.
- H. Expansion joint concealed components to be installed in maximum lengths possible, properly tape and seal tubing and vapor retarder joints. Install roofing system flashing cover over tubing as required to provide a sealed, weathertight condition meeting manufacturer's requirements.
- I. Walkway pads to be installed in accordance with manufacturer's recommendations for an adhered installation to the roofing membrane.

**3.6 PROTECTION**

- A. Roof Traffic: After work on roof is started, no traffic will be permitted on the roof other than that necessary for the roofing application and inspection. Materials shall not be piled on the roof to the extent that the original structural design live and dead loads are exceeded. Roofing materials shall not be transported over unfinished or finished roofing unless adequate protection is provided. Any damage to previously installed roofs shall be repaired at no expense to Owner.
- B. Protection against damage: Surfaces shall be protected as necessary to prevent damage resulting from the application of roofing, or transporting of materials. If surfaces are damaged in any way they shall be repaired, restored, or replaced by the contractor, at no cost to the Owner, in a manner acceptable to the Architect and Owner.

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**PART 4 - ADJUST AND CLEAN**

- A. Adjustment and Repair: Any roofing damaged or misapplication shall be repaired or replaced as required at no expense to Owner.
- B. Remove debris from the roofing areas and job site. Legally dispose of debris.
- C. Remove tools, equipment, and construction aids.
- D. Prevent storage of materials and equipment on the completed roof. Any damage to previously installed roofs shall be repaired at no expense to Owner.

**END OF SECTION 07 5424**



**SECTION 07 7100**  
**PREFABRICATED ROOF SPECIALTIES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified under this section.

**1.2 SCOPE OF WORK**

- A. Work under this section shall include, but not necessarily be limited to the following:
  - 1. Metal fascia, copings, counterflashing, gutters, downspouts, curb mounted expansion joints.
  - 2. Pipe supports, pipe boots, roof curbs.
  - 3. Roof hatches.
  - 4. Walkway pads.
  - 5. Downspout nozzles for outflow at roof area overflows.
  - 6. Concrete splashblocks.
  - 7. Roof curb metal caps.

**1.3 SUBMITTALS**

- A. Product data
- B. Shop drawings
- C. Samples of finish color on metal.
- D. Letter from NRCA stating that manufacturer and/or shop fabricator is a NRCA Authorized Fabricator of ANSI/SPRI ES-1 components and systems.
- E. Prior to fabrication, submit certification that edge securement components meet requirements of ANSI/SPRI ES-1, and Roofing System Manufacturer's requirements for the specified full system warranty.
- F. Warranty

**1.4 QUALITY ASSURANCE**

- A. Materials, components and installation procedures shall be in accordance with Roofing System Manufacturer's requirements for the specified full system warranty.
- B. Edge securement components shall meet requirements of ANSI/SPRI ES-1, and Roofing System Manufacturer's requirements for the specified full system warranty.
- C. Manufacturer and/or shop fabricator shall be a NRCA Authorized Fabricator of ANSI/SPRI ES-1 components and systems meeting Roofing System Manufacturer's requirements for the specified full system warranty.
- D. Installing contractor must have proven experience record on projects of similar scope, and requirements including but not limited to water tightness, aesthetics, adherence to design intent, coordination of components, provide and maintain manufacturers

warranties, etc.

#### **1.5 PROJECT CONDITIONS**

- A. Coordinate Work with adjacent Work, including installation of roofing system to prevent roofing terminations being left unprotected.

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

- A. Deliver materials in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, and directions for storage.
  - 1. Materials shall be delivered to the site in an undamaged and dry condition.
  - 2. Material received which is not dry or is otherwise damaged shall be rejected.

#### **1.7 WARRANTY**

- A. Prefinished Metal: Furnish a written 20 year non-prorated manufacturer's warranty on finish and material for pre-finished metal items.
  - 1. Metal Roof Edge and Copings: Products as specified and required by Roofing System Manufacturer to provide the specified full system warranty.
- B. Roof Hatch: Provide manufacturer's standard written warranty. Materials shall be free of defects in material and workmanship for a period of five years. Should a part fail to function in normal use within this period, manufacturer shall furnish a new part at no charge.

### **PART 2 - PRODUCTS**

#### **2.1 METAL COPING AND FASCIA SYSTEM**

- A. Two piece pre-manufactured system:
  - 1. Edge securement components meet requirements of ANSI/SPRI ES-1.
  - 2. Materials and components as required by Roofing System Manufacturer to provide the specified full system warranty.
- B. Coping:
  - 1. Material: 24-gauge galvanized steel; Sizes and shapes as indicated on drawings.
  - 2. Concealed cleat attachment on the outside, exposed fasteners with neoprene gaskets on the inside
  - 3. Finish: Kynar 500. Color as selected by Architect from manufacturer's full range of non-metallic colors.
  - 4. Provide pre-manufactured accessories, concealed splice plates, corner assemblies, miters, etc.
  - 5. Manufacturers:
    - a. Petersen Aluminum Corp.: PAC-TITE
    - b. OMG Roofing Products: Permasnap
    - c. Metal ERA: Perma-Tite

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- d. Manville: Presto Lock
    - e. Roofing System Manufacturers comparable products as required by the specified full system warranty. Above products may be used only if approved in writing by the Roofing System Manufacturer.
  - 6. If approved in writing by the Roofing System Manufacturer as meeting the specified full system warranty requirements, Contractor may use shop-fabricated sheet metal for certain specific components in lieu of specified pre-manufactured system components only due to reasons generated by the Roofing System Manufacturer. In addition to the specified full system warranty requirements, the Contractor certifies in writing prior to fabrication the following:
    - a. Shop-fabricated components meet minimum thickness required by NRCA recommended details which comply with ANSI/SPRI ES-1 requirements or the specified thicknesses, whichever is more.
    - b. Shop-fabricated components were installed in strict accordance with NRCA recommended details which comply with ANSI/SPRI ES-1 requirements.
    - c. Shop-fabricated components are watertight and weathertight.
  - 7. Field-fabricated metal components are not acceptable.
- C. Fascia:
  - 1. Material: 24-gauge prefinished galvanized steel; Sizes and shapes as indicated on drawings.
  - 2. Factory-made, 2-piece with water dam and snap-on cover, designed for specified roofing system.
  - 3. Finish: Kynar 500. Color as selected by Architect from manufacturer's full range of non-metallic colors.
  - 4. Provide pre-manufactured accessories, concealed splice plates, corner assemblies, miters, scuppers, etc.
  - 5. Manufacturers:
    - a. Petersen Aluminum Corp.: PAC-LOC 2000
    - b. OMG Roofing Products: Econosnap
    - c. Metal ERA: Perma-Tite System 200
    - d. Manville: Comparable to above
    - e. Roofing System Manufacturers comparable products as required by the specified full system warranty
  - 6. If approved in writing by the Roofing System Manufacturer as meeting the specified full system warranty requirements, Contractor may use shop-fabricated sheet metal for certain specific components in lieu of specified pre-manufactured system components only due to reasons generated by the Roofing System Manufacturer. In addition to the specified full system warranty requirements, the Contractor certifies in writing prior to fabrication the following:

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- a. Shop-fabricated components meet minimum thickness required by NRCA recommended details which comply with ANSI/SPRI ES-1 requirements or the specified thicknesses, whichever is more.
  - b. Shop-fabricated components were installed in strict accordance with NRCA recommended details which comply with ANSI/SPRI ES-1 requirements.
  - c. Shop-fabricated components are watertight and weathertight.
7. Field-fabricated metal components are not acceptable.

**2.2 MISCELLANEOUS PREFINISHED METAL ITEMS**

- A. Shop fabricated metal counterflashing, gutters, scuppers, downspouts, valley flashings, mechanical equipment flashings, roof edge flashings, fascias and copings on projects without a full system warranty.
- 1. Edge securement components meet requirements of ANSI/SPRI ES-1.
  - 2. Contractor shall certify in writing the following:
    - a. Shop-fabricated components meet minimum thickness required by NRCA recommended details which comply with ANSI/SPRI ES-1 requirements or the specified thicknesses, whichever is more.
    - b. Shop-fabricated components were installed in strict accordance with NRCA recommended details which comply with ANSI/SPRI ES-1 requirements.
    - c. Shop-fabricated components are watertight and weathertight.
  - 3. Field-fabricated metal components are not acceptable.
- B. 24-gauge prefinished galvanized steel by:
- 1. Petersen Aluminum Corp.: Pac-Clad
  - 2. Firestone: Una-Clad
- C. Shop fabricated, shapes and sizes as indicated.
- D. Finish: Kynar 500, color as selected by Architect from manufacturer's full range of non-metallic colors.
- 1. Valley flashings and mechanical equipment flashings to match shingles and may be different color from other items.

**2.3 PIPE SUPPORTS**

- A. Conduit, gas piping, HVAC piping, etc to be supported above roof surface with prefabricated pipe supports. Non-metallic support base with height adjustable galvanized metal bracket type at single conduit and piping, and adjustable channel strut guide type at multiple adjacent conduit and piping runs. Provide roller guide type accessory at gas lines.
- 1. Portable Pipe Hangers Inc.
  - 2. Cooper Industries, B-Line

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3. Miro Industries, Inc.
4. OMG Roofing Products.
5. Roofing System Manufacturers comparable products as required by the specified full system warranty.

**2.4 PIPE BOOTS**

- A. Prefabricated EPDM pipe boot cover
  1. Portals Plus, Inc.
  2. OMG Roofing Products.
  3. Roofing System Manufacturers comparable products as required by the specified full system warranty.
- B. Provide proper single boot or multiple boot cap system as required by the conditions.

**2.5 WALKWAY PADS**

- A. Walkway Pads: Provide manufacturer standard walkway pads around perimeter of roof mounted equipment requiring access or service including roof hatches, stairs, ladders, mechanical exhaust fans, air handling units, condensing units, etc. Individual walkway pads shall be nominal 30" by 30".

**2.6 ROOF HATCH**

- A. Roof hatch shall be 2'-6" x 3'-0" single-leaf type, thermally broken, preassembled aluminum unit.
  1. Bilco, Type S-50TB
  2. Babcock-Davis, ThermalMax BRHT
- B. Performance:
  1. Cover and curb shall be thermally broken to prevent heat transfer between interior and exterior surfaces.
  2. Cover shall be reinforced to support a minimum live load of 40 psf with a maximum deflection of 1/150th of the span and 20 psf wind uplift.
  3. Operation of the cover shall be smooth and easy with controlled operation throughout the entire arc of opening and closing, and shall not be affected by temperature.
  4. Entire hatch shall be weather tight with fully welded corner joints on cover and curb.
- C. Cover: 11 gauge minimum aluminum with a 5" beaded flange with formed reinforcing members. Interior and exterior surfaces shall be thermally broken to minimize heat transfer and to resist condensation. Cover shall have a heavy extruded EPDM rubber gasket bonded to the cover interior to assure a continuous seal when compressed to the top surface of the curb.
- D. Insulation: 3" minimum rigid polyisocyanurate with an LTTR-value of 18.0, fully covered and protected by an 18 gauge minimum aluminum liner.

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- E. Curb: 11 gauge minimum aluminum. Interior and exterior surfaces shall be thermally broken to minimize heat transfer and to resist condensation. Curb shall have an integral 11 gauge aluminum capflashing fully welded at the corners. Curb to have 5" minimum mounting flange with height to allow for 12" minimum clearance from final roof surface to bottom of capflashing flange. Top of curb to be level, curb to be tapered as required.
  - 1. Insulation: 3" minimum rigid polyisocyanurate with an LTTR-value of 18.0.
- F. Lifting mechanisms: Compression spring operators enclosed in telescopic tubes.
- G. Hardware
  - 1. Heavy stainless steel pintle hinges.
  - 2. Cover shall be equipped with a spring latch with interior and exterior turn handles
  - 3. Hatch shall be equipped with interior padlock hasps.
  - 4. Latch strike shall be a stamped component bolted to the curb assembly.
  - 5. Cover shall automatically lock in the open position with a rigid hold open arm equipped with a vinyl grip handle to permit easy release for closing.
  - 6. Compression spring tubes shall be an anti-corrosive composite material and all other hardware shall be zinc plated and chromate sealed.
  - 7. Cover hardware shall be bolted into heavy gauge channel reinforcing welded to the underside of the cover and concealed within the insulation space.
- H. Finishes: Mill finish aluminum.
- I. Ladder safety post for attachment to roof access ladder with safety yellow finish.
  - 1. Bilco, LadderUP Safety Post, Model LU-1.
  - 2. Babcock-Davis, BSP

## **2.7 EQUIPMENT CURBS/RAILS**

- A. Prefabricated, load bearing equipment curbs/rails, double wall 18 gauge minimum galvanized steel with continuous welded and mitered corner seams and internal wood blocking with rigid insulation fill. Provide with integral base mounting plate and counterflashing.
  - 1. The Pate Company
  - 2. RPS Accessories
  - 3. Hranec Sheet Metal Inc.

## **2.8 DOWNSPOUT NOZZLE**

- A. Cast bronze OR cast nickel bronze (Nikaloy) downspout nozzle, manufacturers standard OR satin finish, with integral wall mounting flange for secure masonry wall attachment. Provide with integral heavy gauge stainless steel bird screen option. Provide proper hub for type of pipe connection required. Sizes required as indicated for each pipe connection.
  - 1. Josam, 25010 Series
  - 2. Jay R. Smith Mfg. Co., 1770 Series

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3. MIFAB Inc., R1940 Series

**2.9 SPLASHBLOCKS**

- A. Precast concrete splashblocks, sizes indicated, at downspout discharge locations. Portland cement, white or gray (all units to match), sand and aggregate mix producing 4,500psi minimum compressive strength, with 5% - 7% air entrainment, reinforced with grade 60 steel manufacturers standard reinforcement. Units to have 3" minimum height on three sides, dished and sloping to discharge end of 1-1/2" minimum thickness. Properly designed and fabricated to control drainage down and away from downspout.
  - 1. Units on roof surfaces to be set on roofing manufacturers specified walkway pads, full coverage and a minimum of 6" larger than the splashblock in all directions.

**2.10 ROOF CURB METAL CAPS**

- A. Existing abandoned roof curbs to remain without use are to be capped with a weathertight, insulated, one piece galvanized metal cap as indicated.
- B. Cap to be shop fabricated, 14 gauge minimum galvanized steel with continuous 3" minimum perimeter flange with drip edge, overlapping exterior edges of roof curb on all four sides, with maximum vertical gap of 1/4". Any seams and joints to be fully welded and sealed. Cap to be fully insulated with 5" total thickness polyisocyanurate rigid board insulation, consisting of two layers fully adhered together and to underside of cap, and abutting inside faces of roof curb. Caps with either dimension exceeding 48" to have horizontal surface cross broken for strength, with peak on exterior side. In addition, caps with either dimension exceeding 60" to be reinforced with concealed 3 x 3 x 14 gauge galvanized steel bent angles spanning the short dimension at 24" centers, tack welded to underside of cap. Follow current SMACNA recommendations.
  - 1. Steel to be commercial quality hot-dipped zinc coated steel that complies with ASTM A653, Coating Designation A60 (Galvanealed).
  - 2. Touch-up any seams, welds, and exposed edges with galvanized paint.
  - 3. Rigid insulation to be closed cell polyisocyanurate foam board, foil faced, square edges, maximum flame spread 25 and smoke developed indexes of 450. ASTM C 1289 Type I Class 1 Grade 3, 25 psi minimum compressive strength, ASTM D 1621. Minimum LTTR-R Value of 28.8.

**PART 3 - EXECUTION**

**3.1 INSTALLATION - GENERAL**

- A. Comply with manufacturer's instructions and recommendations. Coordinate with installation of roof deck and other substrates to receive roof accessory units, and with roof insulation, roofing and flashing; as required to ensure that each element of the work performs properly, and that combined elements are waterproof and weathertight. Anchor units securely to supporting structural substrates, adequate to withstand lateral and thermal stresses as well as inward and outward loading pressures.
  - 1. Except as otherwise indicated install roof accessory items in accordance with construction details of "NRCA Roofing and Waterproofing Manual".
  - 2. Follow NRCA recommended details which comply with ANSI/SPRI ES-1 requirements for edge securement items.

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- B. Where metal surfaces of units are to be installed in contact with non-compatible metal or corrosive substrates, including wood, apply bituminous coating on concealed metal surfaces, or provide other permanent separation.
- C. Flange Seals: Except as otherwise indicated, set flanges of accessory units in a thick bed of approved roofing sealant to form a seal.
- D. Operational Units: Test operate units with operable components. Clean and lubricate joints and hardware. Adjust for proper operation.

**3.2 INSTALLATION – PRE-MANUFACTURED COPING AND FASCIA**

- A. Install two-piece pre-manufactured coping and fascia system components per manufacturer's requirements.
- B. Provide necessary components, accessories, trim, etc. to provide a complete and proper finished weathertight condition.
- C. Provide manufacturers concealed interlocking splice plates at section joints, properly sealed to provide a weathertight condition and allow for expansion. Lapped joints or exposed cover plates are not acceptable.

**3.3 INSTALLATION – SHOP FABRICATED METAL**

- A. Counterflashing to be set on continuous bead of caulk and secured to wall construction with neoprene gasketed non-corrosive fasteners of the proper type for the supporting substrate at 12" centers. Provide one piece and two piece as indicated. Top edge at one piece to be caulked continuous.
  - 1. Sections to be lapped 4" and fully sealed.
- B. Fascias and copings where approved to be shop fabricated, shall be applied to wood backing as detailed and in accordance with manufacturer's recommendations with continuous 22 ga. minimum galvanized metal cleats.
  - 1. Provide concealed 12" closure at section joints of same material, caulked in to provide a weathertight condition and allow for expansion. Provide 3/8" joint between sections centered on closure.
- C. Provide necessary components, accessories, trim, etc. to provide a complete and proper finished weathertight condition.
- D. Rake ends to be drain lapped 3" minimum.
- E. Miscellaneous metal wall flashings to be installed in longest sections possible to minimize joints. Securely fasten concealed to solid substrate backup with non-corrosive flat head fasteners. Joints to be lapped 3" minimum with vertical/horizontal surfaces set together on beads of sealant to ensure watertight condition.
- F. Concealed non-corrosive fasteners to be utilized wherever possible. Exposed fasteners to be non-corrosive, Kynar 500 finish matching adjacent metal.
- G. Exposed edges and cut edges of prefinished metal to be properly treated, and finished, matching faces to provide a finished, corrosion free appearance.

**3.4 INSTALLATION – MISCELLANEOUS ROOF COMPONENTS**

- A. Install miscellaneous roof components per manufacturer's recommendations to provide complete and proper weathertight installation.



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- B. Skylight roof curbs to be securely anchored to roof structure and properly sealed and flashed to provide a complete and proper finished weathertight condition for the items indicated, meeting manufacturer's requirements.
- C. Install walkway pads in accordance with manufacturer's recommendations.
- D. Roof hatch to be securely anchored to roof structure and associated structural supports. Properly sealed and flashed to provide a complete and proper finished weathertight condition meeting manufacturer's requirements. Install units level, plumb, and in proper alignment with adjacent work.
  - 1. Test units for proper function and adjust until proper operation is achieved.
  - 2. Repair finishes damaged during installation.
  - 3. Restore finishes so no evidence remains of corrective work.
- E. Equipment curbs and rails to be securely anchored to roof structure and associated structural supports. Properly sealed and flashed to provide a complete and proper finished weathertight condition for the roof supported equipment, meeting manufacturer's requirements.
- F. Downspout nozzles to be installed where indicated. Properly seal drain pipe to nozzle assembly as required by type of pipe connection. Secure nozzle assembly to masonry walls with drilled non-corrosive expansion anchors. Seal assembly flange weathertight meeting manufacturer's requirements.

**3.5 INSTALLATION - ROOF CURB METAL CAPS**

- A. Existing abandoned roof curbs to remain: After removal of existing mechanical equipment, conduit, piping, ductwork, etc. by licensed tradesman, repair any damage to the existing roof curb to provide a stable, sound weathertight condition. Extend top of curb as required by the new top of roof surface elevation to provide 8" minimum exposed height of vertical roof flashing after cap is set in place.
- B. Set cap on existing roof curb with a continuous bead of silicone sealant along top surface of curb. Secure cap at 8" centers through the perimeter cap flange with non-corrosive neoprene gasketed fasteners of the proper type for existing material to be anchored to.
- C. Caulk bottom drip edge of perimeter cap flange to the roof curb with silicone sealant. Include incidentals, etc. as needed to provide a complete and proper, secure, weathertight installation.

**3.6 CLEANING AND PROTECTION**

- A. Remove protective film where applicable. Clean exposed surfaces in accordance with manufacturer's instructions.
- B. Touch up damaged coatings and exposed metal edges with manufacturers Kynar touch up paint.

**END OF SECTION 07 7100**



**SECTION 07 8413**  
**THROUGH-PENETRATION FIRESTOP SYSTEMS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified.

**1.2 SUBMITTALS**

- A. Product Data

**1.3 QUALITY ASSURANCE**

- A. Installer Qualifications: An experienced installer who has completed firestop systems similar in material, design, and extent to that indicated for this Project and familiar with the requirements and restrictions/limitations of the Firestop Contractors International Associations (FCIA) manual of practice and factory mutual research approved.
- B. Source Limitations: Obtain through-penetration firestop systems, for each kind of penetration and construction condition indicated, from a single manufacturer.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Subject to compliance with requirements provide products by one of the following:
  - 1. Grace Construction Products
  - 2. Hilti, Inc.
  - 3. Johns Manville
  - 4. 3M Fire Protection Products
  - 5. Tremco, Inc. Tremco Fire Protection Systems Group
  - 6. USG Corporation

**2.2 PENETRATION 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. Penetrations in Fire-Resistance-Rated Walls: Ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01- inch wg.
  - 1. F-Rating: Not less than the fire-resistance rating of construction penetrated.
- C. Penetrations in Horizontal Assemblies: Ratings determined per ASTM E 814 or UL 1479 based on a positive pressure differential of 0.01-inch wg.
  - 1. F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.
  - 2. T-Rating: A least 1 hour, but not less than the fire-resistance rating of the constructions penetrated except for floor penetrations within the cavity of a wall.

- D. Exposed Penetration Firestopping: Provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.
- E. 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.

### **2.3 SYSTEM FIRE SAFING**

- A. Manufacturers, subject to system manufacturer's approval:
  - 1. Certaineed: Thermafiber
  - 2. Johns Manville: MinWool Safing
  - 3. Owens Corning: Safing Insulation/MW
  - 4. Industrial Insulation Group, LLC; MinWool Safing
- B. Description: Unfaced mineral wool fire rated safing, thicknesses as required for the system. Greenguard Indoor Air Quality Certified.
- C. Ratings: Non-combustible, ASTM E136; Three hour fire resistance rating, ASTM E119, UL 263, NFPA 251; Flame spread rating 5 and smoke developed rating 0, ASTM E84, UL 723.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Examine substrates and conditions for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- B. Surface Cleaning: Clean out openings immediately before installing through-penetration firestop systems to comply with written recommendations of firestop system manufacturer and the following requirements:
  - 1. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of through-penetration firestop systems.
  - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with through-penetration firestop systems. Remove loose particles remaining from cleaning operation.
  - 3. Remove laitance and form-release agents from concrete.
- C. Priming: Prime substrates where recommended in writing by through-penetration firestop system manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
- D. Install penetration firestopping to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.
- E. 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 indicated.
  - 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestopping.

- F. Install fill materials for firestopping by proven techniques to produce the following results:
  - 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items as required to achieve fire-resistance ratings indicated.
  - 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.

### **3.2 FIRE SAFING**

- A. Install fire safing per manufacturer's requirements to obtain required Fire Rating, Flame Spread and Smoke Developed ratings. Fill gaps fully and seal with systems fire caulk.

### **3.3 IDENTIFICATION**

- A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:
  - 1. The words: "Warning--Through-Penetration Firestop System--Do Not Disturb. Notify Building Management of Any Damage."
  - 2. Contractor's name, address, and phone number.
  - 3. Date of installation.
  - 4. Through-penetration firestop system manufacturer's name.
  - 5. Installer's name.

### **3.4 CLEANING AND PROTECTION**

- A. Clean off excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not damage materials in which openings occur.
- B. Provide final protection and maintain conditions during and after installation that ensure through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce through-penetration firestop systems complying with specified requirements.

**END OF SECTION 07 8413**



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**SECTION 07 9200  
JOINT SEALANTS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified in this section.

**1.2 PERFORMANCE REQUIREMENTS**

- A. Provide and install elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.
- B. Provide and install joint sealants for interior applications that establish and maintain airtight and water-resistant continuous joint seals without staining or deteriorating joint substrates.

**1.3 SUBMITTALS**

- A. Product Data indicating specific location(s) where submitted material(s) is to be installed.
- B. Color Samples consisting of strips of cured sealants showing the full range of colors available for each product exposed to view and indicating specific location(s) where submitted material(s) is to be installed.
- C. Warranty

**1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle materials in compliance with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

**1.5 PROJECT CONDITIONS**

- A. Environmental Limitations: Do not proceed with installation of joint sealants under the following conditions:
  - 1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer.
  - 2. When joint substrates are wet.
- B. Joint-Width Conditions: Do not proceed with installation of joint sealants where joint widths are less than those allowed by joint sealant manufacturer for applications indicated.
- C. Joint-Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with adhesion are removed from joint substrates.

**1.6 WARRANTY**

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- A. Installer's Warranty: Submit written warranty, signed by Installer agreeing to repair or replace work that does not comply with performance and other requirements specified herein within Two (2) years from Substantial Completion date.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

- A. Perimeter caulking, exterior, at louvers, window and door frames, masonry control joints, and other joints between wood and masonry, metal and masonry, metal and wood, metal flashings, metal copings, metal fascias, conduit, piping, and other dissimilar materials shall be silicone building sealant by:
1. Dow Corning, 790 Building Sealant
  2. GE, SCS2000 SilPruf
  3. Pecora, 864NST
  4. Tremco, Spectrem 1
- B. Perimeter caulking, interior, at louvers, window and door frames, and other joints between wood and masonry, metal and masonry, metal and wood, conduit, piping, and other dissimilar materials shall be paintable white acrylic siliconized building sealant:
1. Pecora, AC-20 + Silicone
  2. GE, SCS7000 Paintable
  3. Tremco, Tremflex 834
- C. Perimeter caulking, interior, along hard surface finish flooring or floor slabs, at metal door and sidelight frames, steel columns, other metal and wood terminations/joints, etc. shall be colored acrylic siliconized building sealant:
1. Pecora, AC-20 + Silicone
  2. GE, SCS7000
  3. Tremco, Tremflex 834
- D. Sealing of interior concrete floor slab control joints, construction joints, expansion joints (including perimeter expansion joints at walls), cracks, penetrations through the floor slab, and cast in floor devices to be polyurethane building sealant:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. BASF/MasterSeal: NP 2 and SL 2.
    - b. Pecora: Dynatrol II and Dynatrol II SG or NR-200
  2. Sealant shall be flush with concrete floor slab. Provide gun grade or pourable as appropriate for the application.
- E. Sealing of exterior concrete slab control joints, expansion joints, penetrations through concrete slab, and cast in items to be high performance, traffic exposure, exterior urethane building sealant:



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1. BASF/MasterSeal
2. Pecora
3. Tremco
4. Sealant shall be flush with concrete slab. Provide gun grade or pourable as appropriate for the application.

F. Colors as selected by Architect.

## **2.2 JOINT SEALANT BACKING**

- A. Provide sealant backings of material and type which are non-staining; are compatible with joint substrates, sealants, primers and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Backer Rod: ASTM C 1330, of type indicated below and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance:
  1. Type C: Closed-cell material with a surface skin, unless open cell is indicated or recommended by sealant manufacturer.
  2. Type O: Open-cell material.
  3. Type B: Bicellular material with a surface skin.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

## **2.3 MISCELLANEOUS MATERIALS**

- A. Primer: Material recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants with joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

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- A. 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:
  - 1. Remove 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.
  - 2. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, 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 from above cleaning operations by vacuuming or blowing out joints with oil-free compressed air. Porous joint surfaces include the following:
    - a. Concrete.
    - b. Masonry.
    - c. GFRC
    - d. Unglazed surfaces of ceramic tile.
  - 3. Remove laitance and form-release agents from concrete.
  - 4. Clean nonporous surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
    - a. Metal.
    - b. Glass.
    - c. Porcelain enamel.
    - d. Glazed surfaces of ceramic tile.
- B. Joint Priming: Prime joint substrates where recommended in writing by joint sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant 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.

### 3.3 INSTALLATION

- A. General: Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations of ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

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- C. Install sealant backings of type 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 back of joints.
- E. Install sealants by proven techniques to 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 provided for each joint configuration.
  - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified 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 sealants from surfaces adjacent to joint.
  - 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
  - 3. Provide concave joint configuration per Figure 5A in ASTM C 1193, unless otherwise indicated.
- G. Use masking tape to protect adjacent surfaces of recessed tooled joints.

### **3.4 CLEANING**

- A. Clean off excess sealants 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.

### **3.5 PROTECTION**

- A. 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. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from the original work.

**END OF SECTION 07 9200**



**SECTION 07 9500  
EXPANSION CONTROL**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of work shown on the drawings and/or specified.

**1.2 SUBMITTALS**

- A. Product Data
- B. Shop Drawings
  - 1. Indicate joint device profiles, dimensions, locations in the Work, affected adjacent construction, anchorage devices, available colors and finish, and locations of splices.
  - 2. Provide details showing intersection between floor areas, floor-to-wall, wall-to-ceiling, corner conditions, transitions between systems, terminations, etc.
- C. Installation Instructions
  - 1. Manufacturer's installation instructions.
- D. Color Samples
  - 1. Manufacturer standard color and finish options for selection.
- E. Assembly Samples
  - 1. Two assembly samples 6 x 6 in. in size illustrating profile, dimension, color, and finish selected.

**PART 2 - PRODUCTS**

**2.1 EXPANSION JOINTS AT NEW/EXISTING CONSTRUCTION**

- A. Interior floor expansion joint at doors shall be surface mounted extruded aluminum saddle type expansion joint cover. Unit shall be pedestrian rated and meet ADA requirements.
  - 1. MM Systems Corp., HSC-C Series / Slab to Slab
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- B. Interior floor expansion joint at walls shall be surface mounted extruded aluminum saddle type expansion joint cover.
  - 1. MM Systems Corp., HSC-C Series / Slab to Wall
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.

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- C. Interior masonry wall expansion joint shall be flexible cellular polyurethane backer with preformed silicone sealing strip.
  - 1. MM Systems Corp., ESS Series
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- D. Fire rated interior gypsum board wall expansion joint shall be surface applied expansion joint system.
  - 1. MM Systems Corp., FSWL-100 Fire Rated
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- E. Interior gypsum board ceiling/soffit expansion joint shall be concealed securement, flush expansion joint with flexible cover.
  - 1. MM Systems Corp., VSWL-500
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- F. Exterior masonry wall expansion joint shall be flexible cellular polyurethane backer with preformed silicone bellows seal.
  - 1. MM Systems Corp., SIF Series
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- G. Sizes as required by joint widths and application.

**2.2 METAL EXPANSION JOINTS**

- A. Interior floor expansion joint shall be classic curved expansion joint cover with recessed flange to accept floor finish. Unit shall be pedestrian rated and meet ADA requirements.
  - 1. MM Systems Corp., Model HFXR
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- B. Interior wall expansion joint shall be surface applied expansion joint system.
  - 1. MM Systems Corp., Model FXK and FXL
  - 2. Architectural Art, comparable to 1 above.
  - 3. Balco, Inc., comparable to 1 above.
- C. Interior ceiling expansion joint shall be expansion joint with accordion flexible filler. Color as selected by Architect.
  - 1. MM Systems Corp., Model CX (ACT ceiling) and KX (Gypsum board)
  - 2. Architectural Art, comparable to 1 above.

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3. Balco, Inc., comparable to 1 above.
- D. Exterior wall expansion joint shall be silicone expansion joint system. Provide extruded aluminum cover plate, width to be 2" greater than the maximum joint opening width. Anchor cover plate to one side of joint only.
  1. MM Systems Corp., Model HFXR
  2. Architectural Art, comparable to 1 above.
  3. Balco, Inc., comparable to 1 above.
- E. Sizes as required by joint widths and application.

## **2.3 MISCELLANEOUS REQUIREMENTS**

- A. Materials:
  1. Extruded Aluminum: 6063-T5
  2. Threaded Fasteners: Manufacturers standard non-corrosive
  3. Silicone Seal and integral Foam Backer: Colored silicone surface seal factory applied to secondary micro-cell self-expanding foam with impregnated acrylic polymer, watertight, UV stable, flame resistant, chemical resistant meeting ASTM 283, ASTM 518, DIN 18542
  4. Elastomeric Seals: ASTM E 1783; preformed elastomeric membranes or extrusions to be installed in metal frames.
  5. Compression Seals: ASTM E 1612; preformed elastomeric extrusions having an internal baffle system and designed to function under compression.
  6. Fire Barriers: Manufacturers standard to meet performance criteria for required fire-resistance rating.
  7. Protective Coatings: Isolate dissimilar materials with manufacturers standard protective coatings for the proper application.
- B. Finish
  1. Exposed Extruded Sections on Floors: Mill finish.
  2. Exposed Extruded Sections on Walls and Ceilings: Clear anodized.
  3. Resilient Fillers/Silicone Seals/Elastomeric Seals: Color as selected by Architect from manufacturers full range of non-custom colors.
- C. Back paint components in contact with cementitious materials to prevent electrolysis with manufacturers protective coatings.
- D. Galvanize concealed ferrous metal anchors and fastening devices.
- E. Shop assemble components and package with anchors and fittings.
- F. Provide joint components in single lengths wherever practical. Minimize site splicing.
- G. At fire rated locations, provide comparable unit or add standard components that meets required fire rating.

## **PART 3 - EXECUTION**

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**3.1 PREPARATION**

- A. Provide anchoring devices for installation and embedment. Modify as required to provide secure installation into each substrate.
- B. Provide templates or rough-in measurements.

**3.2 INSTALLATION**

- A. Install components and accessories in accord with manufacturer's instructions. Provide necessary sealants, fasteners, etc. required for each system.
- B. Align work plumb and level, flush with adjacent surfaces.
- C. Rigidly anchor and/or adhere to substrate to prevent movement or misalignment.
- D. Provide items and components necessary for continuous transition between roof, wall, floor, and ceiling (soffit) joint covers and as required to provide a uniform finished appearance, and a complete and proper weathertight installation.

**3.3 PROTECTION**

- A. Protect finished installation.
- B. Provide removable strippable coating reinforced cloth tape to protect finish joint surface.

**END OF SECTION 07 9500**



**SECTION 08 1113  
HOLLOW METAL DOORS & FRAMES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified in this section.

**1.2 REFERENCES**

- A. ANSI – American Nations Standards Institute / SDI - Steel Door Institute
  - 1. ANSI A250.4 Test Procedure and Acceptance and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcing.
  - 2. ANSI A250.8/SDI 100 – Recommended Specifications for Standard Steel Doors and Frames
  - 3. ANSI/SDI 250.11 Recommended Erection Instructions for Steel Frames
- B. NFPA – National Fire Protection Association
  - 1. NFPA 80 Standard for Fire Doors and Other Opening Protectives
  - 2. NFPA 105 Standard for Installation of Smoke Door Assemblies
- C. UL – Underwriters Laboratories
  - 1. UL 10C Standard for Safety for Positive Pressure Fire Tests of Door Assemblies
  - 2. UL 1784 Air Leakage Tests of Door Assemblies

**1.3 SUBMITTALS**

- A. Product Data.
- B. Shop Drawings indicating the following:
  - 1. Elevations and dimensions of each door and frame design.
  - 2. Details of doors including vertical and horizontal edge details.
  - 3. Frame details for each frame type including dimensioned profiles.
  - 4. Details and locations of reinforcement and preparations for hardware.
  - 5. Details of each different wall opening condition.
  - 6. Details of anchorages, accessories, joints, and connections.
  - 7. Coordination of glazing frames and stops with glass and glazing requirements.
- C. Door Schedule: Use same reference designations indicated on Drawings in preparing schedule for doors and frames.

**1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain hollow metal doors and frames through one source from a single manufacturer wherever possible.

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- B. Minimum Thickness: Minimum thickness of base metal without coatings according to SDI 250.8.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver doors and frames cardboard-wrapped or crated to provide protection during transit and job storage. Provide additional protection to prevent damage to finish of factory primed doors and frames.
- B. Inspect doors and frames on delivery for damage, and notify shipper and supplier if damage is found. Minor damages may be repaired provided refinished items match new work and are acceptable to Architect. Remove and replace damaged items that cannot be repaired as directed.
- C. Store doors and frames at building site under cover. Place units on minimum 4 inch high wood blocking. Avoid using non-vented plastic or canvas shelters that could create a humidity chamber. If door packaging becomes wet, remove cartons immediately. Provide minimum 1/4 inch spaces between stacked doors to permit air circulation.

**PART 2 - PRODUCTS**

**2.1 EXTERIOR METAL DOORS**

- A. Manufacturers: Subject to requirements below:
  - 1. Steelcraft: B Series
  - 2. Ceco Door: Medallion Series
  - 3. Republic Doors and Frames: DE Series
  - 4. Security Metal Products Corp.: w/ Steel Stiffened Core
  - 5. Curries: 747 Series
- B. Level/Model: Provide Doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A205.4 for physical performance level, except as modified below:
  - 1. Level 3 and Physical Performance Level B (Extra Heavy Duty), minimum 0.053 inch (16 gage) thick steel, Model 2 (Either continuously welded seam dressed smooth or intermittently welded seam, edge filled with epoxy, dressed smooth.)
  - 2. Face Sheets: Face sheets fabricated from commercial quality hot-dipped zinc coated steel that complies with ASTM A653, Coating Designation A60 (Galvanealed).
  - 3. Design: Flush Panel.
  - 4. Thickness: 1-3/4 inch.
  - 5. Core Construction: Vertical Steel Stiffener Core. Minimum 0.026 inch (22 gage) steel stiffeners at 6 inches on center construction attached to face sheets by spot welds spaced not more than 5 inches on center. A60 (Galvanealed). Spaces between stiffeners to be filled with fiberglass insulation (minimum density 0.8 lb./cu.ft).
  - 6. Top and Bottom Edges: Reinforce tops and bottoms of doors with continuous steel channel not less than 0.053 inch (16 gage), extending full width of door and welded to the face sheet. A60 (Galvanealed). Doors with inverted top channel to include a steel closure channel welded in place with the web of the channel flush

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with the face sheets of the door. Seal top against moisture penetration. Plastic or composite filler caps are not permitted. Provide weep-hole openings in bottom of door to allow moisture to escape.

- C. Hardware Reinforcements: Provide and fabricate according to ANSI/SDI A250.6.
  - 1. Continuous Hinge Reinforcement: In addition, at continuous hinges provide a 0.067 inch (14 gauge) continuous channel.
  - 2. Hardware reinforcements in exterior doors to be A60 coated.
- D. Vision Lites: Flush mounted trim lite kit. Mitered corners. Weather tight, stops applied to exterior with security screws.

## 2.2 INTERIOR METAL DOORS

- A. Manufacturers: Subject to requirements below:
  - 1. Steelcraft: L Series
  - 2. Ceco Door: Regent or Legion Series
  - 3. Republic Doors and Frames: DL Series
  - 4. Security Metal Products Corp.: w/ Honeycomb or Polystyrene Core
  - 5. Curries: 707 Series
- B. Level/Model: Provide Doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI A250.4 for physical performance level, except as modified below:
  - 1. Level 3 and Physical Performance Level B (Extra Heavy Duty), minimum 0.053 inch (16 gage) thick steel, Model 2 (Either continuously welded seam dressed smooth or intermittently welded seam, edge filled with epoxy, dressed smooth).
  - 2. Face Sheets: Face sheets fabricated from commercial quality cold rolled steel that complies with ASTM A1008
  - 3. Design: Flush Panel.
  - 4. Thickness: 1-3/4 inch.
  - 5. Core Construction: Kraft-paper Honeycomb or Solid Polystyrene Core
    - a. Kraft-paper Honeycomb: resin impregnated honeycomb core completely filling the inside of door and laminated to inside face of both panels.
    - b. Polystyrene: 1 pound density polystyrene core completely filling the inside of door and laminated to inside face of both panels.
  - 6. Top and Bottom Edges: Reinforce tops and bottoms of doors with continuous steel channel not less than 0.053 inch (16 gage), extending full width of door and welded to the face sheet
- C. Hardware Reinforcements: Provide and fabricate according to ANSI/SDI A250.6.
  - 1. Continuous Hinge Reinforcement: In addition, at continuous hinges provide a 0.067 inch(14 gage) continuous channel.
- D. Vision Lites: Flush mounted trim lite kit. Mitered corners. Stops applied to secure side.

## 2.3 FIRE RATED DOORS

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- A. Manufacturers: Subject to requirements below:
  - 1. Steelcraft: L, B, or T Series
  - 2. Ceco Door: Regent, Legion, Medallion, or 450° Medallion Series
  - 3. Republic Doors and Frames: DE or DL Series
  - 4. Security Metal Products Corp.: w/ Honeycomb or Polystyrene, or w/ Steel Stiffened Core
  - 5. Curries: 707, 727 or 747 Series
- B. In addition to the requirements for Exterior and Interior Doors listed above Fire Rated Doors shall conform to the following:
  - 1. Testing: Fire Door assemblies shall conform to the requirements of UL10C Positive Pressure Fire Tests of Door Assemblies.
  - 2. Rating Label: Label from third party certification agency, showing the hourly rating of the door shall be permanently attached in a visible location. Labels may be metal or mylar. testing agency to be:
    - a. Underwriters Laboratories
    - b. Warnock-Hersey International, Inc.
  - 3. Smoke and Draft Control: In addition to the required fire protection rating smoke and draft control doors shall be tested in accordance with UL 1784 and have an "S" Label.
  - 4. Temperature Rise: Where required by the applicable Building Code, Fire Rated Doors shall comply with requirements for 450°F Temperature Rise Rating.
  - 5. Rated doors scheduled for protection plates must be approved application of scheduled protection plates.
- C. Vision Lites: Manufacturer's standard flush mounted trim lite kit for rated doors. Mitered corners. Stops applied to secure side. Coordinate thickness with required fire rated glazing.

## 2.4 STILE & RAIL DOORS

- A. Manufacturers: Subject to requirements below:
  - 1. Steelcraft: A16 Series
  - 2. Ceco Door: Similar to 1 above.
  - 3. Republic Doors and Frames: Similar to 1 above.
  - 4. Security Metal Products Corp.: Similar to 1 above.
  - 5. Curries: Similar to 1 above.
- B. Level/Model: Provide Doors complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and model and ANSI/SDI for physical performance level, except as modified below:
  - 1. Level 3 and Physical Performance Level B (Extra Heavy Duty), minimum 0.053 inch (16 gage) thick steel, Model 3 Stile and Rail.
  - 2. Thickness: 1-3/4 inch.

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- C. Construction:
  - 1. Vertical Stiles: tubular shape, full height of door with no visible seams. Rails are internally welded or permanently mechanically joined to stiles forming a neat seam on the face.
  - 2. Top and Bottom rails: tubular with inverted 0.067 inch (14 gage) welded channel. Provide weather tight flush cap at exterior doors.
  - 3. Intermediate rail: Similar to top and bottom rail.
  - 4. Exterior doors to be fabricated from commercial quality hot-dipped zinc coated steel that complies with ASTM A653, Coating Designation A60 (Galvanealed).
- D. Hardware Reinforcements: Provide and fabricate according to ANSI/SDI A250.6.
  - 1. Continuous Hinge Reinforcement: In addition, at continuous hinges provide a 0.067 inch (14 gage) continuous channel.
- E. Vision Lites: Screwless aluminum glazing beads.

**2.5 DOOR FRAMES AND BORROW LITES**

- A. Manufacturers: Subject to requirements below:
  - 1. Steelcraft: F Series
  - 2. Ceco Door: SU Series
  - 3. Republic Doors and Frames: Standard
  - 4. Security Metal Products Corp.: Standard
  - 5. Curries: M Series
- B. Level/Model: Provide Frames complying with requirements indicated below by referencing ANSI/SDI A250.8 for level and ANSI/SDI A250.4 for physical performance level, except as modified below:
  - 1. Level 3 and Physical Performance Level B (Extra Heavy Duty), minimum 0.053 inch (16 gage) thick steel
  - 2. Exterior frames fabricated from commercial quality hot-dipped zinc coated steel that complies with ASTM A653, Coating Designation A60 (Galvanealed).
    - a. Include galvanealed components and internal reinforcements with galvanealed frames.
  - 3. Fire Rated frames shall conform to the requirements of UL10C Positive Pressure Fire Tests of Door Assemblies.
    - a. Rating Label: Label from third party certification agency shall be permanently attached in a visible location. Labels may be metal or mylar. Testing agency to be:
      - 1. Underwriters Laboratories
      - 2. Warnock-Hersey International, Inc.
- C. Hollow Metal Panels
  - 1. Provide hollow metal panels of same materials, construction and finish as specified for adjoining hollow metal work.

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2. Fire Rated panels shall be 1/2 inch laminated panels with mineral board core or per manufacturer's standard to meet required fire rating.

D. Frame Reinforcement and Accessories

1. Hardware Reinforcements: Provides and fabricate according to ANSI/SDI A250.6.
  - a. Provide adequate reinforcements for other hardware as required.
  - b. Include galvanized hardware reinforcements in galvanealed frames
2. Grout Guards: Weld guards to frame at back of hardware mortises in frames to be grouted.
3. Provide polystyrene blocking at bottom of frame to prevent grout infill in lower 12" of frame.
4. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers.
5. Provide full height 3/8" to 1-1/2" thick strip of polystyrene foam blocking at non-labeled frames requiring grouting where continuous hinges are specified. Apply the strip to the back of the frame, where the hinge is to be installed, to facilitate field drilling or tapping.
6. Stops and Moldings: Provide stops and moldings around glazed lites, panels, and louvers where indicated. Form corners of stops and moldings with butted hairline joints.
  - a. Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
  - b. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames.
  - c. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.
7. Frame Anchors
  - a. Jamb Anchors: – Provide a minimum of three anchors per jamb. Frames over 7 foot 6 inches shall be provided with an additional anchor
    1. Masonry Type: Adjustable strap-and-stirrup or T-shaped anchors to suit frame size, not less than 0.042 (18 gage) thick, with corrugated or perforated straps not less than 2 inches wide by 10 inches long; or wire anchors not less than 0.177 inch (#7) thick.
    2. Stud-Wall Type: Designed to engage stud, welded to back of frames; not less than 0.042 inch (18 gage) thick.
    3. Postinstalled Expansion Type for In-Place Concrete or Masonry: Minimum 3/8 inch diameter bolts with expansion shields or inserts. Provide pipe spacer from frame to wall, with throat reinforcement plate, welded to frame at each anchor location.

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- b. Floor Anchors: Formed from same material as frames, minimum thickness of 0.042 inch (18 gage), and as follows:
  - 1. Clip-type anchors, with two holes to receive fasteners.
  - 2. Adjustable-type anchors with extension clips, allowing not less than 2-inch height adjustment. Terminate bottom of frames at finish floor surface.
  - 3. Where wall or floor conditions do not allow for use of floor anchors an additional jamb anchor shall be acceptable.
- E. Fabrication
  - 1. Flush Frames: Set-up and welded with temporary shipping bars. Factory die-mitered corner connections reinforced with four integral tabs to secure and interlock at jambs to head. Unless otherwise indicated, frames will have 2" faces and 5/8" stops. Face dimensions and width of frames as indicated on the drawings.
  - 2. Frames are to be assembled so that the face miter seam is "closed and tight". Weld the face seam and the full web of the frame corner or intersection. Grind and dress smooth the weld area. For exterior frames apply a zinc rich primer over the grinding areas. For frames, finish with a matching prime paint.
  - 3. When shipping limitations so dictate, frames for large openings shall be fabricated in sections designed for splicing or splining in the field. Joints in the field shall be as above.

## 2.6 FINISHES

- A. Prime Finish: Doors and frames to be cleaned, and chemically treated to insure maximum finish paint adhesion. Surfaces to receive manufacturer's standard, factory-applied coat of rust-inhibiting primer complying with ANSI A250.10 for acceptance criteria.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrate, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Contractor to verify accuracy of dimensions given to the steel door and frame manufacturer for existing openings or existing frames.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Hollow Metal Frames: Install hollow-metal frames of size and profile indicated. Comply with SDI A250.11.
  - 1. Prior to installation, frames must be checked for rack, twist, and out of square conditions. Set frames accurately in position; plumbed, aligned and braced securely until permanent anchors are set. After wall construction is complete and walls are properly set and secured, remove temporary braces, leaving surfaces smooth and undamaged.

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- a. Install fire rated doors and frames in accordance with NFPA-80.
  - b. Install smoke and draft control doors in accordance with NFPA 105.
- 2. At exterior frames install removable stops on exterior side with security screws. At interior frames install removable stops on secure side.
- 3. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, and secure with postinstalled expansion anchors.
- 4. Grouting Frames: Frames in masonry shall be grouted solid. Frames to receive grouting shall comply with ANSI/SDI A250.8. Mortar is not acceptable substitute for grout.
  - a. Install silencers and polystyrene blocks in frame before grouting.
  - b. Grout will be mixed to provide a 4" maximum slump consistency and hand troweled into place.
  - c. Do not use grout mixed to a thinner, pumpable consistency; this practice is not recommended and not permissible.
  - d. Grout must not contain any gypsum bearing components.
  - e. Only grout jambs attached to walls. Heads are not to be grouted. Horizontal and vertical mullions are not to be grouted.
  - f. Provide wood spreaders as required to maintain proper width and avoid bowing or deforming of frame members.
- B. Installation of Hollow Metal Doors
  - 1. Fit hollow metal doors accurately in frames, with in clearances specified below. Shim as necessary.

### 3.3 INSTALLATION TOLERANCES

- A. Doors and Frames shall be installed to tolerances specified in ANSI/SDI A250.11, NFPA 80 and as below:
  - 1. Frames
    - a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on line 90 degrees from jam perpendicular to frame head.
    - b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
    - c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
    - d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.
  - 2. Doors
    - a. Measured on pull face of the door.
    - b. Between Door and Frame Jambs and Head: 1/8 inch plus or minus 1/16 inch
    - c. Between Edges of Pairs of Doors: 1/8 inch plus or minus 1/16 inch.



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- d. Between Bottom of Door and Top of Threshold: Maximum 3/8 inch.
- e. Between Bottom of Door and Top of Finish Floor (No Threshold)  
Maximum 3/4 inch.
- f. Between Door Face and Stop: Maximum 1/8 inch.

**3.4 ADJUSTING AND CLEANING:**

- A. Remove grout and other bonding material from hollow metal work immediately after installation.
- B. Prime Coat and Painted Finish Touch-Up: Immediately after erection, sand smooth rusted or damaged areas of prime coat or painted finishes, and apply touch-up of compatible air-drying, rust inhibitive primer or paint
- C. Final Adjustments: Check and re-adjust operating doors and hardware items immediately prior to final inspection. Leave work in complete and proper operating condition.
  - 1. Remove and replace defective work, including doors or frames that are damaged, bowed or otherwise unacceptable.
  - 2. Remove grout and other bonding material from hollow metal work.
- D. Label Verification – Verify that fire rated doors and frames have required labels in a visible location and that these labels have not been painted over.
  - 1. If labels are missing or have been painted over Contractor shall be responsible for having doors and frames inspected and relabeled by a qualified relabeling agency at no additional cost to the Owner.

**PART 4 - PROTECTION**

- A. Provide protective measures required throughout the construction period to ensure that door and frame units will be without damage or deterioration, other than normal weathering, at time of acceptance.
  - 1. Protect from construction activities and associated materials that could have detrimental effects to the door and frame material and finish.

**END OF SECTION 08 1113**



**SECTION 08 7100**  
**FINISH HARDWARE**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes commercial door hardware for the following:
1. Swinging doors.
  2. Sliding doors.
  3. Other doors to the extent indicated.
- B. Door hardware includes, but is not necessarily limited to, the following:
1. Mechanical door hardware.
  2. Cylinders specified for doors in other sections.
- C. Related Sections:
1. Division 08 Section "Hollow Metal Doors and Frames".
  2. Division 08 Section "Flush Wood Doors".
  3. Division 08 Section "Aluminum-Framed Entrances and Storefronts".
- D. Codes and References: Comply with the version year adopted by the Authority Having Jurisdiction.
1. ANSI A117.1 - Accessible and Usable Buildings and Facilities.
  2. ICC/IBC - International Building Code.
  3. NFPA 70 - National Electrical Code.
  4. NFPA 80 - Fire Doors and Windows.
  5. NFPA 101 - Life Safety Code.
  6. NFPA 105 - Installation of Smoke Door Assemblies.
  7. State Building Codes, Local Amendments.
- E. Standards: All hardware specified herein shall comply with the following industry standards as applicable. Any undated reference to a standard shall be interpreted as referring to the latest edition of that standard:
1. ANSI/BHMA Certified Product Standards - A156 Series.
  2. UL10C - Positive Pressure Fire Tests of Door Assemblies.
  3. ANSI/UL 294 - Access Control System Units.
  4. UL 305 - Panic Hardware.

5. ANSI/UL 437- Key Locks.

### 1.3 SUBMITTALS

- A. Product Data: Manufacturer's product data sheets including installation details, material descriptions, dimensions of individual components and profiles, operational descriptions and finishes.
- B. Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final Door Hardware Schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
  1. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule."
  2. Organization: Organize the Door Hardware Schedule into door hardware sets indicating complete designations of every item required for each door or opening. Organize door hardware sets in same order as in the Door Hardware Sets at the end of Part 3. Submittals that do not follow the same format and order as the Door Hardware Sets will be rejected and subject to resubmission.
  3. Content: Include the following information:
    - a. Type, style, function, size, label, hand, and finish of each door hardware item.
    - b. Manufacturer of each item.
    - c. Fastenings and other pertinent information.
    - d. Location of door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
    - e. Explanation of abbreviations, symbols, and codes contained in schedule.
    - f. Mounting locations for door hardware.
    - g. Door and frame sizes and materials.
    - h. Warranty information for each product.
  4. Submittal Sequence: Submit the final Door Hardware Schedule at earliest possible date, particularly where approval of the Door Hardware Schedule must precede fabrication of other work that is critical in the Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the Door Hardware Schedule.
- C. Keying Schedule: After a keying meeting with the owner has taken place prepare a separate keying schedule detailing final instructions. Submit the keying schedule in electronic format. Include keying system explanation, door numbers, key set symbols, hardware set numbers and special instructions. Owner must approve submitted keying schedule prior to the ordering of permanent cylinders/cores.
- D. Informational Submittals:
  1. Product Test Reports: Indicating compliance with cycle testing requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified independent testing agency.

- E. Operating and Maintenance Manuals: Provide manufacturers operating and maintenance manuals for each item comprising the complete door hardware installation in quantity as required in Division 01, Closeout Procedures.

#### **1.4 QUALITY ASSURANCE**

- A. Manufacturers Qualifications: Engage qualified manufacturers with a minimum 5 years of documented experience in producing hardware and equipment similar to that indicated for this Project and that have a proven record of successful in-service performance.
- B. Certified Products: Where specified, products must maintain a current listing in the Builders Hardware Manufacturers Association (BHMA) Certified Products Directory (CPD).
- C. Installer Qualifications: A minimum 3 years documented experience installing both standard and electrified door hardware similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- D. Door Hardware Supplier Qualifications: Experienced commercial door hardware distributors with a minimum 5 years documented experience supplying both mechanical and electromechanical hardware installations comparable in material, design, and extent to that indicated for this Project. Supplier recognized as a factory direct distributor by the manufacturers of the primary materials with a warehousing facility in Project's vicinity. Supplier to have on staff a certified Architectural Hardware Consultant (AHC) available during the course of the Work to consult with Contractor, Architect, and Owner concerning both standard and electromechanical door hardware and keying.
- E. Source Limitations: Obtain each type and variety of door hardware specified in this section from a single source unless otherwise indicated.
  - 1. Electrified modifications or enhancements made to a source manufacturer's product line by a secondary or third party source will not be accepted.
- F. Each unit to bear third party permanent label demonstrating compliance with the referenced standards.
- G. Keying Conference: Conduct conference to comply with requirements in Division 01 Section "Project Meetings." Keying conference to incorporate the following criteria into the final keying schedule document:
  - 1. Function of building, purpose of each area and degree of security required.
  - 2. Plans for existing and future key system expansion.
  - 3. Requirements for key control storage and software.
  - 4. Installation of permanent keys, cylinder cores and software.
  - 5. Address and requirements for delivery of keys.
- H. Pre-Submittal Conference: Conduct coordination conference in compliance with requirements in Division 01 Section "Project Meetings" with attendance by representatives of Supplier(s), Installer(s), and Contractor(s) to review proper methods and the procedures for receiving, handling, and installing door hardware.
  - 1. Prior to installation of door hardware, conduct a project specific training meeting to instruct the installing contractors' personnel on the proper installation and adjustment of their respective products. Product training to be attended by installers of door hardware

(including electromechanical hardware) for aluminum, hollow metal and wood doors. Training will include the use of installation manuals, hardware schedules, templates and physical product samples as required.

2. Inspect and discuss electrical roughing-in, power supply connections, and other preparatory work performed by other trades.
  3. Review sequence of operation narratives for each unique access controlled opening.
  4. Review and finalize construction schedule and verify availability of materials.
  5. Review the required inspecting, testing, commissioning, and demonstration procedures
- I. At completion of installation, provide written documentation that components were applied to manufacturer's instructions and recommendations and according to approved schedule.

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

- A. Inventory door hardware on receipt and provide secure lock-up and shelving for door hardware delivered to Project site. Do not store electronic access control hardware, software or accessories at Project site without prior authorization.
- B. Tag each item or package separately with identification related to the final Door Hardware Schedule, and include basic installation instructions with each item or package.
- C. Deliver, as applicable, permanent keys, cylinders, cores, access control credentials, software and related accessories directly to Owner via registered mail or overnight package service. Instructions for delivery to the Owner shall be established at the "Keying Conference".

#### **1.6 COORDINATION**

- A. Templates: Obtain and distribute to the parties involved templates for doors, frames, and other work specified to be factory prepared for installing standard and electrified hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing hardware to comply with indicated requirements.
- B. Door and Frame Preparation: Doors and corresponding frames are to be prepared, reinforced and pre-wired (if applicable) to receive the installation of the specified electrified, monitoring, signaling and access control system hardware without additional in-field modifications.

#### **1.7 WARRANTY**

- A. General Warranty: Reference Division 01, General Requirements. Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Warranty Period: Written warranty, executed by manufacturer(s), agreeing to repair or replace components of standard and electrified door hardware that fails in materials or workmanship within specified warranty period after final acceptance by the Owner. Failures include, but are not limited to, the following:
  1. Structural failures including excessive deflection, cracking, or breakage.
  2. Faulty operation of the hardware.
  3. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

4. Electrical component defects and failures within the systems operation.
- C. Standard Warranty Period: One year from date of Substantial Completion, unless otherwise indicated.
- D. Special Warranty Periods:
  1. Twenty five years for manual overhead door closer bodies.

## **1.8 MAINTENANCE SERVICE**

- A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

## **PART 2 - PRODUCTS**

### **2.1 SCHEDULED DOOR HARDWARE**

- A. General: Provide door hardware for each door to comply with requirements in Door Hardware Sets and each referenced section that products are to be supplied under.
- B. Designations: Requirements for quantity, item, size, finish or color, grade, function, and other distinctive qualities of each type of door hardware are indicated in the Door Hardware Sets at the end of Part 3. Products are identified by using door hardware designations, as follows:
  1. Named Manufacturer's Products: Product designation and manufacturer are listed for each door hardware type required for the purpose of establishing requirements. Manufacturers' names are abbreviated in the Door Hardware Schedule.
- C. Substitutions: Requests for substitution and product approval for inclusive mechanical and electromechanical door hardware in compliance with the specifications must be submitted in writing and in accordance with the procedures and time frames outlined in Division 01, Substitution Procedures. Approval of requests is at the discretion of the architect, owner, and their designated consultants.

### **2.2 HANGING DEVICES**

- A. Hinges: ANSI/BHMA A156.1 certified butt hinges with number of hinge knuckles and other options as specified in the Door Hardware Sets.
  1. Quantity: Provide the following hinge quantity:
    - a. Two Hinges: For doors with heights up to 60 inches.
    - b. Three Hinges: For doors with heights 61 to 90 inches.
    - c. Four Hinges: For doors with heights 91 to 120 inches.
    - d. For doors with heights more than 120 inches, provide 4 hinges, plus 1 hinge for every 30 inches of door height greater than 120 inches.

2. Hinge Size: Provide the following, unless otherwise indicated, with hinge widths sized for door thickness and clearances required:
  - a. Widths up to 3'0": 4-1/2" standard or heavy weight as specified.
  - b. Sizes from 3'1" to 4'0": 5" standard or heavy weight as specified.
3. Hinge Weight and Base Material: Unless otherwise indicated, provide the following:
  - a. Exterior Doors: Heavy weight, non-ferrous, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate standard weight.
  - b. Interior Doors: Standard weight, steel, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate heavy weight.
4. Hinge Options: Comply with the following:
  - a. Non-removable Pins: With the exception of electric through wire hinges, provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for the all out-swinging lockable doors.
5. Manufacturers:
  - a. Hager Companies (HA).
  - b. McKinney Products; ASSA ABLOY Architectural Door Accessories (MK).
  - c. Stanley Hardware (ST).

## **2.3 CYLINDERS AND KEYING**

- A. General: Cylinder manufacturer to have minimum (10) years experience designing secured master key systems and have on record a published security keying system policy.
- B. Source Limitations: Obtain each type of keyed cylinder and keys from the same source manufacturer as locksets and exit devices, unless otherwise indicated.
  1. Manufacturers:
    - a. Sargent Manufacturing (SA).
- C. Cylinder Types: Original manufacturer cylinders able to supply the following cylinder formats and types:
  1. Threaded mortise cylinders with rings and cams to suit hardware application.
  2. Rim cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.
  3. Bored or cylindrical lock cylinders with tailpieces as required to suit locks.
  4. Tubular deadlocks and other auxiliary locks.
  5. Mortise and rim cylinder collars to be solid and recessed to allow the cylinder face to be flush and be free spinning with matching finishes.
  6. Keyway: Match Facility Standard.
- D. Keying System: Each type of lock and cylinders to be factory keyed.



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1. Supplier shall conduct a "Keying Conference" to define and document keying system instructions and requirements.
  2. Furnish factory cut, nickel-silver large bow permanently inscribed with a visual key control number as directed by Owner.
  3. Existing System: Field verify and key cylinders to match Owner's existing system.
- E. Key Quantity: Provide the following minimum number of keys:
1. Change Keys per Cylinder: Two (2)
  2. Master Keys (per Master Key Level/Group): Five (5).
  3. Construction Keys (where required): Ten (10).
- F. Construction Keying: Provide construction master keyed cylinders.
- G. Key Registration List (Bitting List):
1. Provide keying transcript list to Owner's representative in the proper format for importing into key control software.
  2. Provide transcript list in writing or electronic file as directed by the Owner.

## 2.4 KEY CONTROL

- A. Key Control Cabinet: Provide a key control system including envelopes, labels, and tags with self-locking key clips, receipt forms, 3-way visible card index, temporary markers, permanent markers, and standard metal cabinet. Key control cabinet shall have expansion capacity of 150% of the number of locks required for the project.
1. Manufacturers:
    - a. Lund Equipment (LU).
    - b. MMF Industries (MM).
    - c. Telkee (TK).
- P. Electronic Key Management System: Provide an electronic key control system with Stand-alone Plug and Play features including advanced RFID technology. Touchscreen interface with PIN access for keys individually locked in place. Minimum 1,000 system users and 21 iFobs for locking receptors. System shall have a minimum 250,000 audit events screen displayed or ability to be exported via USB port.
1. Manufacturers:
    - a. Medeco (MC).
    - b. Traka (TA).

## 2.5 MECHANICAL LOCKS AND LATCHING DEVICES

- A. Cylindrical Locksets, Grade 1 (Heavy Duty): ANSI/BHMA A156.2, Series 4000, Operational Grade 1 Certified Products Directory (CPD) listed.
1. Vertical Impact: Exceed 100 vertical impacts (20 times ANSI/BHMA A156.2 requirements).

2. Furnish with solid cast levers, standard 2 3/4" backset, and 1/2" (3/4" at rated paired openings) throw brass or stainless steel latchbolt.
3. Locks are to be non-handed and fully field reversible.
4. Manufacturers:
  - a. Sargent Manufacturing (SA) - 10X Line.
  - b. No Substitution.

## **2.6 LOCK AND LATCH STRIKES**

- A. Strikes: Provide manufacturer's standard strike with strike box for each latch or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, unless otherwise indicated, and as follows:
  1. Flat-Lip Strikes: For locks with three-piece antifriction latchbolts, as recommended by manufacturer.
  2. Extra-Long-Lip Strikes: For locks used on frames with applied wood casing trim.
  3. Aluminum-Frame Strike Box: Provide manufacturer's special strike box fabricated for aluminum framing.
  4. Double-lipped strikes: For locks at double acting doors. Furnish with retractable stop for rescue hardware applications.
- B. Standards: Comply with the following:
  1. Strikes for Mortise Locks and Latches: BHMA A156.13.
  2. Strikes for Bored Locks and Latches: BHMA A156.2.
  3. Strikes for Auxiliary Deadlocks: BHMA A156.36.
  4. Dustproof Strikes: BHMA A156.16.

## **2.7 CONVENTIONAL EXIT DEVICES**

- A. General Requirements: All exit devices specified herein shall meet or exceed the following criteria:
  1. At doors not requiring a fire rating, provide devices complying with NFPA 101 and listed and labeled for "Panic Hardware" according to UL305. Provide proper fasteners as required by manufacturer including sex nuts and bolts at openings specified in the Hardware Sets.
  2. Where exit devices are required on fire rated doors, provide devices complying with NFPA 80 and with UL labeling indicating "Fire Exit Hardware". Provide devices with the proper fasteners for installation as tested and listed by UL. Consult manufacturer's catalog and template book for specific requirements.
  3. Except on fire rated doors, provide exit devices with hex key dogging device to hold the pushbar and latch in a retracted position. Provide optional keyed cylinder dogging on devices where specified in Hardware Sets.

4. Devices must fit flat against the door face with no gap that permits unauthorized dogging of the push bar. The addition of filler strips is required in any case where the door light extends behind the device as in a full glass configuration.
  5. Lever Operating Trim: Where exit devices require lever trim, furnish manufacturer's heavy duty escutcheon trim with threaded studs for thru-bolts.
    - a. Lock Trim Design: As indicated in Hardware Sets, provide finishes and designs to match that of the specified locksets.
    - b. Where function of exit device requires a cylinder, provide a cylinder (Rim or Mortise) as specified in Hardware Sets.
  6. Vertical Rod Exit Devices: Where surface or concealed vertical rod exit devices are used at interior openings, provide as less bottom rod (LBR) unless otherwise indicated. Provide dust proof strikes where thermal pins are required to project into the floor.
  7. Narrow Stile Applications: At doors constructed with narrow stiles, or as specified in Hardware Sets, provide devices designed for maximum 2" wide stiles.
  8. Dummy Push Bar: Nonfunctioning push bar matching functional push bar.
  9. Rail Sizing: Provide exit device rails factory sized for proper door width application.
  10. Through Bolt Installation: For exit devices and trim as indicated in Door Hardware Sets.
- B. Conventional Push Rail Exit Devices (Heavy Duty): ANSI/BHMA A156.3, Grade 1 Certified Products Directory (CPD) listed panic and fire exit hardware devices furnished in the functions specified in the Hardware Sets. Exit device latch to be stainless steel, pullman type, with deadlock feature.
1. Manufacturers:
    - a. Sargent Manufacturing (SA) - 80 Series.
    - b. No Substitution.

## **2.8 DOOR CLOSERS**

- A. All door closers specified herein shall meet or exceed the following criteria:
1. General: Door closers to be from one manufacturer, matching in design and style, with the same type door preparations and templates regardless of application or spring size. Closers to be non-handed with full sized covers.
  2. Standards: Closers to comply with UL-10C for Positive Pressure Fire Test and be U.L. listed for use of fire rated doors.
  3. Size of Units: Comply with manufacturer's written recommendations for sizing of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Where closers are indicated for doors required to be accessible to the Americans with Disabilities Act, provide units complying with ANSI ICC/A117.1.

4. Closer Arms: Provide heavy duty, forged steel closer arms unless otherwise indicated in Hardware Sets.
  5. Closers shall not be installed on exterior or corridor side of doors; where possible install closers on door for optimum aesthetics.
  6. Closer Accessories: Provide door closer accessories including custom templates, special mounting brackets, spacers and drop plates as required for proper installation. Provide through-bolt and security type fasteners as specified in the hardware sets.
- B. Door Closers, Surface Mounted (Large Body Cast Iron): ANSI/BHMA A156.4, Grade 1 Certified Products Directory (CPD) listed surface mounted, heavy duty door closers with complete spring power adjustment, sizes 1 thru 6; and fully operational adjustable according to door size, frequency of use, and opening force. Closers to be rack and pinion type, one piece cast iron body construction, with adjustable backcheck and separate non-critical valves for closing sweep and latch speed control.
1. Manufacturers:
    - a. Corbin Russwin Hardware (RU) - DC8000 Series.
    - b. Norton Rixson (NO) - 9500 Series.
    - c. Sargent Manufacturing (SA) - 281 Series.

## **2.9 ARCHITECTURAL TRIM**

- A. Door Protective Trim
1. General: Door protective trim units to be of type and design as specified below or in the Hardware Sets.
  2. Size: Fabricate protection plates (kick, armor, or mop) not more than 2" less than door width (LDW) on stop side of single doors and 1" LDW on stop side of pairs of doors, and not more than 1" less than door width on pull side. Coordinate and provide proper width and height as required where conflicting hardware dictates. Height to be as specified in the Hardware Sets.
  3. Where plates are applied to fire rated doors with the top of the plate more than 16" above the bottom of the door, provide plates complying with NFPA 80. Consult manufacturer's catalog and template book for specific requirements for size and applications.
  4. Protection Plates: ANSI/BHMA A156.6 certified protection plates (kick, armor, or mop), fabricated from the following:
    - a. Stainless Steel: 300 grade, .050-inch thick.
  5. Options and fasteners: Provide manufacturer's designated fastener type as specified in the Hardware Sets. Provide countersunk screw holes.
  6. Manufacturers:
    - a. Hiawatha, Inc. (HI).
    - b. Rockwood (RO).

- c. Trimco (TC).

## **2.10 DOOR STOPS AND HOLDERS**

- A. General: Door stops and holders to be of type and design as specified below or in the Hardware Sets.
- B. Door Stops and Bumpers: ANSI/BHMA A156.16, Grade 1 certified door stops and wall bumpers. Provide wall bumpers, either convex or concave types with anchorage as indicated, unless floor or other types of door stops are specified in Hardware Sets. Do not mount floor stops where they will impede traffic. Where floor or wall bumpers are not appropriate, provide overhead type stops and holders.
  - 1. Manufacturers:
    - a. Hiawatha, Inc. (HI).
    - b. Rockwood (RO).
    - c. Trimco (TC).

## **2.11 ARCHITECTURAL SEALS**

- A. General: Thresholds, weatherstripping, and gasket seals to be of type and design as specified below or in the Hardware Sets. Provide continuous weatherstrip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated. At exterior applications provide non-corrosive fasteners and elsewhere where indicated.
- B. Smoke Labeled Gasketing: Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke control ratings indicated, based on testing according to UL 1784.
  - 1. Provide smoke labeled perimeter gasketing at all smoke labeled openings.
- C. Fire Labeled Gasketing: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UL-10C.
  - 1. Provide intumescent seals as indicated to meet UL10C Standard for Positive Pressure Fire Tests of Door Assemblies, and NPFA 252, Standard Methods of Fire Tests of Door Assemblies.
- D. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated.
- E. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.
- F. Manufacturers:
  - 1. National Guard Products (NG).
  - 2. Pemko (PE).

## **2.12 FABRICATION**

- A. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to manufacturers recognized installation standards for application intended.

## **2.13 FINISHES**

- A. Standard: Designations used in the Hardware Sets and elsewhere indicate hardware finishes complying with ANSI/BHMA A156.18, including coordination with traditional U.S. finishes indicated by certain manufacturers for their products.
- B. Provide quality of finish, including thickness of plating or coating (if any), composition, hardness, and other qualities complying with manufacturer's standards, but in no case less than specified by referenced standards for the applicable units of hardware
- C. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.
- B. Notify architect of any discrepancies or conflicts between the door schedule, door types, drawings and scheduled hardware. Proceed only after such discrepancies or conflicts have been resolved in writing.

### **3.2 PREPARATION**

- A. Hollow Metal Doors and Frames: Comply with ANSI/DHI A115 series.
- B. Wood Doors: Comply with ANSI/DHI A115-W series.

### **3.3 INSTALLATION**

- A. Install each item of mechanical and electromechanical hardware and access control equipment to comply with manufacturer's written instructions and according to specifications.
  - 1. Installers are to be trained and certified by the manufacturer on the proper installation and adjustment of fire, life safety, and security products including: hanging devices; locking devices; closing devices; and seals.
- B. Mounting Heights: Mount door hardware units at heights indicated in following applicable publications, unless specifically indicated or required to comply with governing regulations:

1. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
  2. DHI TDH-007-20: Installation Guide for Doors and Hardware.
  3. Where indicated to comply with accessibility requirements, comply with ANSI A117.1 "Accessibility Guidelines for Buildings and Facilities."
  4. Provide blocking in drywall partitions where wall stops or other wall mounted hardware is located.
- C. Retrofitting: Install door hardware to comply with manufacturer's published templates and written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
- D. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."
- E. Storage: Provide a secure lock up for hardware delivered to the project but not yet installed. Control the handling and installation of hardware items so that the completion of the work will not be delayed by hardware losses before and after installation.

### **3.4 FIELD QUALITY CONTROL**

- A. Field Inspection (Punch Report): Reference Division 01 Sections "Closeout Procedures". Produce project punch report for each installed door opening indicating compliance with approved submittals and verification hardware is properly installed, operating and adjusted. Include list of items to be completed and corrected, indicating the reasons or deficiencies causing the Work to be incomplete or rejected.
1. Organization of List: Include separate Door Opening and Deficiencies and Corrective Action Lists organized by Mark, Opening Remarks and Comments, and related Opening Images and Video Recordings.

### **3.5 ADJUSTING**

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

### **3.6 CLEANING AND PROTECTION**

- A. Protect all hardware stored on construction site in a covered and dry place. Protect exposed hardware installed on doors during the construction phase. Install any and all hardware at the latest possible time frame.
- B. Clean adjacent surfaces soiled by door hardware installation.

- C. Clean operating items as necessary to restore proper finish. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of owner occupancy.

### 3.7 DEMONSTRATION

- A. Instruct Owner's maintenance personnel to adjust, operate, and maintain mechanical and electromechanical door hardware.

### 3.8 DOOR HARDWARE SETS

- A. The hardware sets represent the design intent and direction of the owner and architect. They are a guideline only and should not be considered a detailed hardware schedule. Discrepancies, conflicting hardware and missing items should be brought to the attention of the architect with corrections made prior to the bidding process. Omitted items not included in a hardware set should be scheduled with the appropriate additional hardware required for proper application and functionality.
1. Quantities listed are for each pair of doors, or for each single door.
  2. The supplier is responsible for handling and sizing all products.
  3. Where multiple options for a piece of hardware are given in a single line item, the supplier shall provide the appropriate application for the opening.
  4. At existing openings with new hardware the supplier shall field inspect existing conditions prior to the submittal stage to verify the specified hardware will work as required. Provide alternate solutions and proposals as needed.
- B. Manufacturer's Abbreviations:

1. MK - McKinney
2. MR - Markar
3. RO - Rockwood
4. SA - SARGENT
5. RF - Rixson
6. PE - Pemko
7. CR - Curries (Hardware Only)
8. OT - Other
9. SU - Securitron

#### **Hardware Sets**

##### **Set: G1.00**

6 Hinge, Full Mortise	TA2714 4-1/2" x 4-1/2"	US26D	MK
1 Self-Latching Flushbolt Set	2845	US32D	RO
1 Dust Proof Strike	570	US26D	RO
1 Coordinator	2600 Series	Blk	RO
2 Coordinator Mounting Bracket	2601 Series	Blk	RO



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1	Storeroom Lock	41 10XG04 LL	US26D	SA
2	Surface Closer	281 CPS	EN	SA
2	Kick Plate	K1050 8" high 4BE CSK	US32D	RO
1	Threshold	171A		PE
1	Head Gasketing	S773D		PE
1	Adjustable Gasketing Set	379CPK		PE
2	Sweep	18061CNB		PE
1	Adjustable Surf. Mtd. Astragal Set	351C/CS		PE

Notes: Install S773D at head  
install 379CPK at vertical jamb

END OF SECTION 08 7100



**SECTION 09 2900  
GYPSUM BOARD SYSTEM**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified under this section.
- B. Provide Level 1 gypsum board level of finish to unexposed gypsum board. At fire rated and/or smoke partitions provide additional requirements meeting codes.
- C. Provide Level 4 gypsum board level of finish to exposed gypsum board to receive paint finish unless otherwise noted.

**1.2 SUBMITTALS**

- A. Product Data

**1.3 QUALITY ASSURANCE**

- A. Gypsum Association standards and recommendations
  - 1. GA-214 - Recommended Levels of Gypsum Board Finish.
  - 2. GA-216 - Application and Finishing of Gypsum Panel Products.
  - 3. GA-290 - Area Separation Walls.
  - 4. GA-600 - Fire Resistance Design Manual.
  - 5. GA-801 – Handling and Storage of Gypsum Panel Products.

**1.4 DESIGN REQUIREMENTS**

- A. Metal Framing: Provide non-load bearing steel stud partitions with deflections conforming to L/240 at 5 psf (239 Pa) typical for gypsum board walls.
- B. Fire-Resistive Rating: Where indicated on Drawings, provide materials and construction that are identical to those assemblies whose fire resistance rating has been determined per ASTM E119 by a testing and inspecting organization acceptable to authorities having jurisdiction.
  - 1. Meet or exceed fire resistance requirements outlined under provisions of the GA-600 Fire Resistance Design Manual for wall and ceiling assemblies.
  - 2. Meet or exceed Class A flame/fuel/smoke requirements of ASTM E84 surface burning characteristics for finish materials.

**PART 2 - PRODUCTS**

**2.1 FRAMING MATERIALS**

- A. Steel studs, framing, runners, furring, and associated system components: ASTM C645, 30 mil (20ga) galvanized, sizes indicated. Subject to compliance with requirements, provide products by one of the following.
  - 1. Gypsum Board Manufacturer Products

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2. ClarkDietrich
  3. United States Steel
  4. Marinoware
- B. Deflection Track: Steel sheet top runner manufactured to prevent cracking of finishes due to deflection of structure above. Allow for 1" of movement.
1. Fire Rated Locations: Provide Fire Trak Deflection Trak and Fire Stop System by FireTrak Corp. or comparable fire rated system by metal stud manufacturer.
  2. Non-fire Rated Locations: Provide metal stud manufacturer's slip-type head joint system.

## **2.2 GYPSUM BOARD**

- A. Gypsum Board: ASTM D3273, 5/8" thick, Type X, Mold Resistant with a score of 10 as rated according to ASTM D 3273 and/or 0 as rated according to ASTM G21.
1. U.S Gypsum; Sheetrock Firecode Core, Mold Tough Board
  2. National Gypsum Co.; Gold Bond XP Fire-Shield, Mold Resistant Board
  3. Georgia-Pacific; ToughRock Fireguard X Mold-Guard Gypsum Board
  4. Continental Building Products; Mold Defense Type X
  5. CertainTeed Corp.; M2Tech Type X

## **2.3 TRIM**

- A. Metal Trim and Finishing Accessories: Manufacturers standard zinc galvanized metal edge trim, corner bead, etc. for use at intended application.
- B. Control Joint Trim: 1/4" joint, PVC conforming to ASTM C1047 and D3678 for interior exposure. Include manufacturer's proper intersection and corner trim for continuous monolithic appearance. Mud set type trim with perforated concealed flanges. Provide proper comparable unit rated for exterior exposure at exterior gypsum board soffits. Subject to compliance with requirements, provide products by one of the following:
1. Trim-Tex, Inc., #093V Expansion Joint
  2. Plastic Components, Inc., #2027-16
- C. Reveal Trim: 2" x 2", PVC conforming to ASTM C1047 and D3678 for interior exposure. Include manufacturer's proper intersection and corner trim for continuous monolithic appearance. Mud set type trim with perforated concealed flanges. Provide proper comparable unit rated for exterior exposure at exterior gypsum board soffits. Subject to compliance with requirements, provide products by one of the following:
1. Trim-Tex, Inc., #AS5510 at wall intersection and #AS5110 in field
  2. Plastic Components, Inc., #202 Z Mold Trim at wall intersection and #225 Drywall Reveal in field.

## **2.4 COMPONENTS**

- A. Joint compound, tapes, etc.: Gypsum board manufacturer's premium products matching the specified board type and characteristics. Must maintain indicated mold resistance, fire

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resistance, and abuse resistance. Do not mix manufacturers, provide same manufacturer as board to maintain the integrity of their system.

1. Screws: Type "S" as recommended by gypsum board manufacturer.

### **PART 3 - EXECUTION**

#### **3.1 METAL STUD FRAMING INSTALLATION**

- A. Stud System Erection. Attach metal runners at floor with suitable fasteners located 2" from each end and spaced 16" o.c. Position studs vertically, engaging floor and ceiling runners and spaced 16" o.c. Metal studs shall run full height from floor to height as indicated. When necessary, splice studs with 8" nested lap and one positive attachment per stud flange. Place studs in direct contact with door frame jambs, abutting partitions and partition corners.
- B. Anchor studs for shelf-walls, counter, vanity, and those adjacent to door frames, partition intersections, and corners to ceiling and floor runner flanges with USG Metal Lock Fastener tool. Securely anchor studs to jamb and head anchor clips of door frames by bolt or screw attachment. Over metal door frames, place horizontally a cut-to-length section of runner with a web flange bend at each end, and secure with one positive attachment per flange.
- C. Framing components shall be cut squarely for attachment to perpendicular members, or as required for an angular fit against abutting members. Members shall be held positively in place until properly fastened.
- D. Construct corners using minimum 3 studs, double stud at wall opening, door and windows jambs.
- E. Erect studs 1 piece full length; splicing of studs not permitted.
- F. Attachment of similar materials shall be done by mechanical fasteners. Dissimilar materials may be attached with screws, bolts or properly designed clips. Wire tying of framing components in structural applications shall not be permitted.
- G. Provide necessary stud bracing, etc. as detailed and/or required to support design and anticipated loads.
- H. Install intermediate studs above and below openings to match wall stud spacing.
- I. Provide deflection allowance in stud top track, directly below horizontal building framing for non-load bearing framing. Deflection top track to be installed per manufacturer's requirements to allow for vertical deflection, and fire rating at walls indicated to be fire rated. Provide additional gypsum board layers, etc. required by manufacturer of system.
- J. At locations where the stud top track is not supported on a continuous support, provide misc. items including metal framing, blocking, angles, etc. to properly brace and support the wall.
- K. Install framing between studs for attachment of mechanical and electrical items, and to prevent stud rotation.
- L. Provide substantial intermediate wood blocking properly anchored to metal studs for secure attachment of wall mounted items, toilet accessories, etc.

#### **3.2 GYPSUM BOARD INSTALLATION**

- A. The suspension system for the suspended gypsum board panels, ceilings and soffits shall

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consist of necessary components as required and shall be installed as per manufacturer's requirements and/or as detailed to support loads at 1/360 max. deflection. Provide control joints as indicated and required, installed per manufacturer's requirements. Properly glue and screw gypsum board panels to ceiling suspension system.

- B. Suspension system and components to be supported from steel bar joists including but not necessarily limited to framing and hanging wire shall be supported from the top chord of the steel joists unless otherwise specifically indicated.
- C. Gypsum board erection (on studs). Apply gypsum panels vertically. Position edges over studs for vertical application; ends over studs for horizontal application.
- D. Use maximum practical lengths to minimize end joints. Fit ends and edges closely, but not forced together.
- E. Stagger joints on opposite sides of partition and on laminated sections. Space screws 12" o.c. in field of panels and 8" o.c. staggered along vertical abutting edges.
- F. Gypsum board shall be applied to surfaces where called for the drawings. Joints shall be taped, spackled and neatly sanded to form a smooth even sound surface so as to show no evidence of joints after surfaces have been painted. Provide corner beads at exterior corners and trim at exposed edges of gypsum board surfaces and where gypsum board abuts dissimilar materials, taped flush. Provide indicated level of finish meeting Gypsum Association standards.
- G. Cement board to be provided as the backer board for areas to receive ceramic tile wall finish. Install per manufacturer's requirements.
- H. Exterior gypsum board shall be provided in exterior locations. Install per manufacturer's requirements.
- I. Trim, beads, control joints, reveals, etc. to be taped in flush to provide a uniform monolithic appearance. Installation with mechanical fasteners and adhesives to meet manufacturers requirements.
- J. Work and materials to be per gypsum board manufacturer's requirements to provide and maintain the fire rating, mold resistance, and abuse resistance of their system.

### **3.3 PATCHING**

- A. After other trades and contractors have finished their work, damaged areas shall be patched. The Contractor shall accomplish patching and repainting without cost to the Owner.
  - 1. Touch-up, repair or replace damaged products before Substantial Completion.

### **3.4 PROTECTION**

- A. Protect adjacent finish surfaces from damage due to operations.
- B. Protect installed products until Substantial Completion.

**END OF SECTION 09 2900**

**SECTION 09 5100  
ACOUSTICAL CEILINGS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified in this section.

**1.2 SUBMITTALS**

- A. Product Data
- B. Samples
  - 1. Acoustical Tile, 6" square manufacturers sample, one (1) of each tile type

**1.3 STORAGE AND HANDLING**

- A. Deliver acoustical ceiling panels, suspension system components, and accessories to Site in original, unopened packages and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, direct sunlight, surface contamination or other causes.
- B. Before installing acoustical ceiling panels, permit them to reach room temperature and stabilized moisture content.
- C. Handle acoustical ceiling panels carefully to avoid chipping edges or damaging units in any way.

**1.4 PROJECT CONDITIONS**

- A. Space Enclosure: Do not install interior acoustical ceilings until space is enclosed and weatherproof, wet-work (painting, gypsum board, plastering, tiling, and concrete leveling) in space is completed and dry, work above ceilings is complete, and ambient temperature and humidity conditions will be continuously maintained at values indicated for the Project when occupied for its intended use.

**PART 2 - PRODUCTS**

**2.1 ACOUSTICAL TILE**

- A. Type 'B', lay-in type white tiles, ASTM E84 Class A rated, incombustible mineral tile, 24" x 24" x 5/8" min., reveal trim edges, high temperature and humidity resistant. UL Classified NRC 0.70 min., with CAC 22 min.
  - 1. Armstrong, School Zone Fine Fissured # 1717
  - 2. CertainTeed, Performa Fine Fissured High NRC #HHF-454-HNRC
  - 3. USG Acoustical Products Co., Radar ClimaPlus High-NRC #22121
  - 4. Rockfon, Artic #660

**2.2 METAL SUSPENSION SYSTEMS - GENERAL**

- A. Pre-finish exposed members white. Provide hold down clips in vestibules and as required.

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- B. Provide additional cross tees, adapter clips, and any necessary components for the proper installation of perimeter and multiple layer gypsum board ceilings and feature areas, and mechanical and electrical items to be secured to this system.
- C. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Provide manufacturer's standard edge moldings that fit acoustical panel edge details and suspension systems indicated and that match width and configuration of exposed runners, formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners; provide in longest standard single piece lengths. For penetrations of ceiling, provide edge moldings fabricated to fit penetration exactly. Provide manufacturer's factory fabricated matching trim, inside and outside corners, including matching radius for outside corner bullnose CMU and/or gypsum board wall locations.
- D. Attachment Devices: Size for five times the design load indicated in ASTM C 635, Table 1, "Direct Hung," unless otherwise indicated or recommended by manufacturer.
  - 1. Anchors in Concrete: Provide one of the following types:
    - a. Postinstalled Expansion Anchors: Suitable for application indicated, fabricated from corrosion resistant materials, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing according to ASTM E 488 or ASTM E 1512 as applicable, conducted by a qualified testing and inspecting agency.
      - 1. Corrosion Protection: Carbon-steel components zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition.
    - b. Power-Actuated Fasteners: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to ten times that imposed by ceiling construction, as determined by testing according to ASTM E 1190, conducted by a qualified testing and inspecting agency.
- E. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:
  - 1. Zinc-Coated, Carbon-Steel Wire: ASTM A 641, Class 1 zinc coating, soft temper.
  - 2. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635, Table 1, "Direct Hung") will be less than yield stress of wire, but provide not less than 0.106-inch- diameter (12 gage) wire.

**2.3 LAY-IN SUSPENSION SYSTEM**

- A. Manufacturers:
  - 1. Chicago Metallic Corp./Rockfon, 200 System
  - 2. USG., DX System
  - 3. Armstrong, Prelude XL
  - 4. CertainTeed, Classic



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- B. Standard 15/16" grid.

## **2.4 VERTICAL SUSPENSION TRIM**

- A. Extruded aluminum, 12" straight nominal vertical face, pre-finished white.
  - 1. Rockfon, Infinity Standard Perimeter Trim
  - 2. USG, Compasso Elite
  - 3. Armstrong, Axiom Classic Trim
  - 4. CertainTeed, Cloud Perimeter Trim
- B. Provide manufacturer's factory mitered corner trim, concealed splice plates, etc. and components required to provide a complete and proper, finished installation.
- C. Provide factory curved sections meeting radius as indicated.

## **2.5 HORIZONTAL SUSPENSION TRIM**

- A. Extruded aluminum, 6" nominal horizontal face, sharp edged perimeter, pre-finished white.
  - 1. Rockfon, Infinity Z Perimeter Trim
  - 2. USG, Compasso Slim
  - 3. Armstrong, Axiom Knife Edge
- B. Provide manufacturer's factory mitered corner trim, concealed splice plates, etc. and components required to provide a complete and proper, finished installation.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.
- B. Examine acoustical panels before installation. Acoustical panels that are cracked or damaged, wet, moisture damaged, mold damaged, etc. are not acceptable.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install materials in accordance with ASTM C 636, manufacturer's printed instructions, industry standards applicable to the Work, and requirements of authorities having jurisdiction. Exposed fasteners are not acceptable.
- B. Acoustical ceiling systems and ceiling components to be supported from building structural members. Securely hang ceiling from structural system in an approved manner, capable of supporting a minimum of 25 lbs./sq.ft. Provide additional supports at multiple layer gypsum board areas, mechanical, and electrical items as required.
  - 1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum, which are not part of supporting structural or ceiling

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suspension system.

2. Splay hangers only where required to miss obstructions and offset resulting horizontal force by bracing, counters playing or other equally effective means.
  3. 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.
  4. Do not support ceilings directly from permanent metal forms or composite floor deck. Fasten hangers to cast-in-place hanger inserts, post-installed mechanical or epoxy adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
  5. When steel or wood framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
  6. Do not attach hangers to steel or wood, roof or floor decking. Attach hangers to structural members or top chord of trusses as designed for the ceiling loads.
  7. Space hangers not more than 48 inches o.c. along each member supported directly from hangers, unless otherwise indicated, leveling to tolerance of 1/8 inch per 12 feet. Provide hangers not more than 8-inches from ends of each member. Provide additional hangers and locate hangers as recommended by ceiling manufacturer to support pendant lighting and other similar items.
  8. Secure wire hangers by looping and wire-tying, either directly to structures or to inserts, eye-screws, or other devices which are secure and appropriate for substrate, and which will not deteriorate or fail due to age, corrosion, or elevated temperatures. Secure wire hangers with not less than three (3) full, closely spaced turns.
  9. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications and as indicated.
- C. Set ceilings level with laser beam in straight lines and paralleled with rectangular walls.
- D. Lay out pattern in coordination with other trades to eliminate off-centering of units in tile pattern.
- E. Lay tile pattern out in order that there shall be no tile less than half.
- F. Certain rooms have grilles, recessed light fixtures recessed into ceilings, access panels and other required openings. Where such occur, furring shall be framed properly to permit the installation of such fixtures, panels and openings This Contractor shall install frames, panels, etc., as furnished by the other contractors.
- G. System Runners: Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- H. Ceiling Panels: Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit with edges matching edge design of panel.

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1. Install square-edged panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
2. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces with manufacturers touch-up edge paint.

**3.3 ADJUST AND CLEAN**

- A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Clean exposed surfaces of acoustical ceilings; comply with manufacturer's instructions for cleaning and touch-up of minor finish damage. Remove and replace work, which cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

**END OF SECTION 09 5100**



**SECTION 09 9100  
PAINTING**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Provide labor, materials, equipment and incidentals required for the completion of the work shown on the drawings and/or specified.
- B. The Contractor is directed to read the specification pertaining to the work and materials of other trades in order to understand the extent of various materials used and the provisions regarding their painting. Surfaces that are left unpainted or unfinished shall be finished as part of this work. Complete finished painting is required for every item whether scheduled, noted or not. Work requiring finish but not scheduled or noted shall be finished with products as specified for similar and/or adjacent work.
  - 1. Paint new and existing exposed surfaces unless noted otherwise. If the drawings and/or Schedule of Painting does not specifically mention an item or a surface, paint the item or surface the same as similar adjacent materials or surfaces.
- C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.
  - 1. Prefinished items include, but are not limited to, the following factory-finished components:
    - a. Architectural woodwork.
    - b. Metal lockers.
    - c. Elevator equipment.
    - d. Finished mechanical and electrical equipment.
    - e. Light fixtures and supports.
  - 2. Concealed surfaces refers to surfaces, materials, assemblies, or items that cannot be accessed without moving a building element, such as within a chase, wall, or ceiling cavity; as in the following generally inaccessible spaces:
    - a. Furred areas.
    - b. Ceiling plenums.
    - c. Pipe spaces.
    - d. Duct shafts.
    - e. Elevator shafts.
  - 3. Finished metal surfaces include, but are not limited to, the following:
    - a. Anodized aluminum.
    - b. Stainless steel.
    - c. Chromium plating.
  - 4. Operating parts include moving parts of operating equipment and the following:
    - a. Valve and damper operators.

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- b. Linkages.
- c. Sensing devices.
- d. Motor and fan shafts.
- 5. Labels: Do not paint over:
  - a. UL, FMG, or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.
  - b. Labels designating materials or assemblies as accessible.

## **1.2 QUALITY ASSURANCE**

- A. Single Source Responsibility: Provide primers and undercoat paint produced by the same manufacturer as the finish coats. If single source responsibility is not possible, furnish written approval of manufacturer of finish coat indicating acceptance of proposed under coats.
- B. For shop primed materials by others, verify compatibility between primer and finish coats. Notify the Architect in writing of problems anticipated with using the specified finish coat materials. Where finish coats are incompatible with primer coats or existing finishes, provide additional barrier coat or surface preparation as required by the manufacturer of the primer and finish coats.
- C. Verify compatibility between primer and substrate. Notify the Architect in writing of problems anticipated with using the specified primer and finish coat materials. Where primer and finish coats are incompatible with substrates, for issues such as non-acceptable alkalinity levels, moisture levels, or poor adhesion. Provide additional barrier coat or surface preparation as required by the manufacturer of the primer and finish coats.
- D. Preparatory work to be performed as indicated, and at a minimum shall be performed in strict accordance with coating manufacturer's requirements including applicable Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers International (NACE) standards.

## **1.3 SUBMITTALS**

- A. Product data: Include information regarding recommended usage, drying times, preparation and primers, surface compatibility, and application instructions which are to be followed. Material Safety Data (MSD) sheets are not acceptable as product data and if submitted, will be returned without review and comment.
- B. Schedule: Submit schedule showing materials to be used, locations, and number of coats to be applied. See SCHEDULE OF PAINTING for format.
  - 1. Products listed on the SCHEDULE OF PAINTING have been recommended by the paint system manufacturers for the intended use and establish a level of quality. If the Contractor submits and/or uses the specified products, the Contractor agrees that the specified products are proper for the intended use. If the Contractor does not agree with the use of the specified products, and recommends the use of alternative products, the Contractor shall submit written explanation and supporting data from the manufacturer for the proposed products. If accepted, proposed products shall be covered under the provisions of the warranty.

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- C. Color Samples: Provide manufacturer's color fans and/or samples for color selection purpose. Provide full line of standard, custom and premium colors. Provide samples on actual stock when requested by the Architect.
- D. Verification Samples: Provide "Draw-Downs" of each paint color for verification purposes. Provide actual samples of each stain or varnish on actual stock. Each sample shall be marked on the backside with the manufacturer, material, and color code.
- E. Adhesion Testing Reports: Provide manufacturer's recommended adhesion testing meeting ASTM D 3359 and/or ASTM D 667 as appropriate for substrate being tested. Perform in a non-conspicuous area for each substrate to receive the specified coatings. Do not proceed further until positive results are achieved. Provide additional preparatory work, primer and/or barrier coats, etc. as necessary for proper adhesion; perform additional adhesion testing to confirm proper conditions have been met.
- F. Alkalinity Testing Reports: Provide manufacturer's recommended alkalinity testing of plaster, concrete, and concrete masonry surfaces scheduled to receive paint in order to confirm that surfaces do not exceed manufacturer's required alkalinity levels.
- G. Moisture Testing Reports: Provide manufacturer's recommended moisture testing of concrete, concrete masonry, gypsum board, plaster, wood, finished woodwork, and other non-metallic surfaces scheduled to receive paint in order to confirm that surfaces do not exceed manufacturer's required moisture levels.
- H. Warranty: Submit a written warranty, executed by the Contractor.
- I. Coating Maintenance Manual: At project closeout for Owners Record Documents, provide a coatings maintenance manual including area summary with finish schedule, area detail designating location where each product/color/finish was used, product data pages, material safety data sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used.

**1.4 DELIVERY, STORAGE AND HANDLING**

- A. Materials used on the job shall be stored as recommended by the manufacturer. Storage areas shall be kept neat and clean. Damage to these areas or surrounding areas shall be repaired to original condition by the Contractor. Oily rags, waste, etc., must be removed from the building every night and precautions must be taken to avoid fire or indoor contamination. Paints may not be stored, mixed or applied in rooms which have installed finished flooring without taking necessary methods for protection.

**1.5 PROTECTION OF WORK**

- A. Contractor shall provide drop cloths for protecting the floors and finishes from damage during the execution of the work. When necessary, the Contractor shall remove temporary coverings in order to execute the work and shall replace same in a proper manner. In case the covering cannot be replaced, the Contractor shall protect the work as necessary.
- B. Before painting, remove hardware, accessories, plates, lighting fixtures and other similar items or provide necessary protection of such items. Upon completion of the work, remove protections and reinstall above items. Verify proper operation of affected items and replace damaged items as directed by the Architect.
- C. Contractor shall be responsible for staining of floors or other work, and must either entirely remove the stains or replace the stained materials with materials to match original condition as acceptable to the Architect.

**1.6 PROJECT CONDITIONS**

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- A. Conditions must fall within the paint manufacturers requirements, coordinate with below criteria, the more stringent shall apply.
  - 1. Apply water-based paints only when the temperature of surfaces to be painted and surrounding air temperatures are:
    - a. Exterior surfaces between 50 deg F and 90 deg F.
    - b. Interior surfaces between 60 deg F and 90 deg F.
  - 2. Apply solvent-thinned paints only when the temperature of exterior surfaces to be painted and surrounding air temperatures are between 45 deg F and 95 deg F.
  - 3. Interior and exterior painting shall not be performed when satisfactory results cannot be obtained due to high humidity, excessive temperatures or other conditions affecting application and performance.
    - a. Do not apply in snow, rain, fog, or mist.
    - b. Do not apply when the relative humidity exceeds 85 percent.
    - c. Do not apply at temperatures less than 5 deg F above the dew point
    - d. Do not apply to damp or wet surfaces.
- B. Do not apply paint in areas where dust is being generated or will be generated while the applied paint is drying.
- C. In rooms and spaces where paint is being applied, ensure there is adequate ventilation to allow for proper paint drying, as well as to exhaust paint fumes and minimize odors.

## **1.7 WARRANTY**

- A. The Contractor accepts the responsibility of providing proper workmanship, including but not limited to proper cleaning and preparation of surfaces, proper application of product based upon manufacturer's requirements, and acceptance that specified products are proper for the intended use. Contractor agrees that if paint system fails in any manner, it will be due to improper workmanship. Should any failure occur within the specified warranty period, the Contractor agrees to remedy the affected area(s). Work shall include removal of failing paint system (if necessary or if required by the paint system manufacturer), proper cleaning and preparation of surfaces, proper application of product(s) based upon manufacturer's recommendations and requirements, and use of proper products for intended use.
  - 1. The warranty described above shall cover a period of 2 years from the date of Substantial Completion.
  - 2. An additional warranty shall be issued for areas that have failed and have been corrected. This additional warranty shall cover a period of 2 years from the date of acceptance of the corrected work.
- B. The warranty shall not deprive the Owner of other rights or remedies the Owner may have under other provisions of the Contract Documents, and is in addition to and runs concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**



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- A. Paints, varnishes, enamels, lacquers, stains, paste fillers and similar materials, must be delivered in their original containers with the seals unbroken and labels intact. Materials shall be used only as specified by the manufacturer's label on the container. Thinners and accessory materials shall be of best quality and of reputable brands.
- B. Material Compatibility: Furnish block fillers, primers, finish coat materials, and related materials that are compatible with one another and with the existing painted substrates, as demonstrated by the manufacturer, based on testing or field experience.
- C. Patching Material Compatibility: Furnish surface preparation products, including patching compounds, that are compatible with selected paint products.
- D. Gasoline, benzene or other materials not provided for under this specification shall not be brought on the job site.
- E. Colors shall be selected or approved by Architect. Colors shall be mixed as directed and sample panels shall be submitted for approval. Paint products shall be factory-tinted and not tinted on the job site.
- F. The completed work of the Contractor shall match colors and surface finishes of approved samples. The Contractor shall do additional mixing and blending as necessary to achieve this result.
- G. Rooms and spaces may have wall(s) painted a different color(s) than other walls in the same room. Ceilings, soffits, trim and reveals may be painted a different color(s) than the walls. Steel roof joists, bridging and related work may be painted a different color(s) than the roof deck in areas with exposed structural elements. Ductwork, conduits, piping and other mechanical/electrical items may be painted a different color(s) than surrounding items where such items are exposed.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Examine substrates and conditions under which painting will be performed for compliance with paint application requirements. Comply with the specifications and manufacturer's requirements for condition of surfaces.
  - 1. Conform with manufacturer's requirements for warranty to be furnished by the manufacturer.
- B. Surface preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified herein.
- C. Coordination of Work: Review other Sections in which primers are specified to ensure compatibility of the total system for various substrates.
- D. Test Reports: Review alkalinity, moisture, and adhesion test results.
  - 1. Provide required work and materials necessary to meet specification criteria, and provide for the manufacturer's warranty.
- E. Notify the Architect in writing a minimum of 14 days prior to painting, regarding anticipated problems using the specified materials over substrates previously finished with incompatible materials.
- F. Do not begin to apply paint or finishes until unsatisfactory conditions have been corrected.

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1. The application of paint or finishes shall be an indication of the Contractor's acceptance of the surface.

### 3.2 PREPARATORY WORK

- A. Preparatory work to be performed as indicated, and at a minimum shall be performed in strict accordance with coating manufacturer's requirements including applicable Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers International (NACE) standards.
- B. Surfaces to be painted shall be cleaned free of rust, dirt, foreign and deleterious materials before painting is started. Contractor shall do necessary preparatory work, sizing, sanding, etc. to produce a surface suitable to receive paint, natural finish, etc.
  1. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
  2. Use an appropriate cleaner compatible with the coating systems and surfaces as approved by the coating system manufacturer. Properly repair or replace items damaged by this work if repair work is not acceptable to Architect. Properly protect areas and items not to receive above cleaning methods.
  3. Confirm compatibility of shop applied primers with specified finish coats to determine proper preparatory methods, and if a barrier primer coat is recommended by the coating system manufacturer.
- C. Knots, pitch streaks and sappy spots shall be first touched up with shellac or sealer where the finish calls for paint or enamel.
- D. Provide necessary filling of nail holes, cracks, etc., after the application of the first coat using a putty or filler of a color to match the finish. Putty and filler shall be brought flush with the adjoining surfaces in a neat and workmanlike manner. Necessary filling and repair operations shall also be performed to produce a sound and suitable surface to receive the new paint and finish.
- E. Metal surfaces shall be first washed with appropriate solvent to remove any dirt or grease before applying materials. Where rust or scale is present, surfaces shall be properly cleaned and prepared as required by the manufacturer before painting.
  1. Rust shall be removed by sanding, wire brushing, etc.
    - a. Treat existing surfaces with a rust conversion primer/sealer compatible with the specified finishes.
  2. Shop coats of paint that become marred shall be sanded, cleaned, and touched up with required products. Necessary touch-up operations shall also be performed to produce a sound and suitable surface to receive the new paint and finish.
- F. Galvanized steel should be tested for pre-treatments using the procedure from the National Coil Coaters Association, Technical Bulletin No. II-9 or from ASTM D-2092, Method B201, Volume 06.01. Galvanized metal surfaces that has been treated for wet storage stain control must have the treatment removed prior to painting. If the metal has been treated, solvent clean the steel per SSPC-SP1 and apply a test patch. If adhesion is unacceptable, Brush-Off Blasting per SSPC-SP7/NACE No. 4 is required to remove the treatment.
- G. Existing glossy painted surfaces shall be washed thoroughly with a bi-sodium phosphate solution recommended by the paint manufacturer. Rinse, and allow to dry thoroughly.

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Properly repair or replace items damaged by this work if repair work is not acceptable to Architect. Properly protect areas and items not to receive above cleaning methods.

- H. Test substrates for proper adhesion of paint and finish. Provide manufacturer's recommended adhesion testing meeting ASTM D 3359 and/or ASTM D 667 as appropriate for substrate being tested.
- I. Test plaster, concrete, and concrete masonry surfaces scheduled to receive paint for alkalinity levels in order to confirm that surfaces do not exceed manufacturer's required alkalinity levels. Where alkalinity levels exceed required levels, provide manufacturer's proper high pH blocker primer.
- J. Test surfaces scheduled to receive paint for moisture levels in order to confirm that surfaces do not exceed manufacturer's required moisture levels.
- K. Where concrete and concrete masonry surface moisture levels exceed required levels, provide manufacturer's proper moisture blocker primer.
- L. All other non-metallic surfaces such as gypsum board, plaster, wood, finished woodwork, etc. follow manufacturer's written requirements.
- M. Test substrates for proper paint coverage. Provide manufacturer's recommended dry opacity testing meeting ASTM D 344.
- N. Following required preparatory work, Contractor shall inspect surfaces for suitability to receive the specified paint or finishes. The application of paint or finishes shall be an indication of the Contractor's acceptance of the surface.

### 3.3 APPLICATION

- A. Painting products shall be applied in strict accordance with manufacturer's requirements.
  - 1. Drying time of primer, initial finish coat, and subsequent finish coats is temperature and humidity dependent and must follow the manufacturer's requirements before any coats are applied.
  - 2. Cure time of the completed coating application is temperature and humidity dependent and must follow the manufacturer's requirements for a fully cured painted surface before any further contractual work occurs to the painted surface, or that could adversely affect the painted surface.
    - a. Painted surfaces must be fully cured prior to installing items subject to direct contact with said surfaces.
- B. Materials shall be thoroughly mixed immediately before application of paint. Materials shall be evenly spread and smoothly flowed on without runs or sags or other defects.
- C. Painting and finishing shall not be done while surfaces are damp. Coats shall be thoroughly dry and cured before applying succeeding coats. Interior work except on masonry, pipe covering or other soft or rough surfaces, shall be sanded between coats with fine sandpaper to produce an even, smooth finish, unless otherwise specified.
- D. Final interior finish coat shall not be applied until other work has been finished and materials and debris have been removed and the premises have been left in a broom clean condition.
  - 1. Painted surfaces must be fully cured prior to installing items subject to direct contact with said surfaces.
- E. Final exterior finish coat shall not be applied until other work has been finished and materials and debris have been removed.

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1. Painted surfaces must be fully cured prior to installing items subject to direct contact with said surfaces.

### **3.4 WORKMANSHIP**

- A. Workmanship shall be of the very best. Only skilled mechanics shall be employed.
- B. Finish work shall be uniform and of approved color and shall be smooth, free from runs, sags and defective application. Edges of paint adjoining other materials or colors shall be sharp and clean, without overlapping. Before applying succeeding coats, primers and undercoats shall be completely integral and performing the function for which they are specified. Scratches, abrasions or any other disfigurements shall be properly prepared, sanded, and touched up, and any foreign matter removed before proceeding with the following coat.
- C. Paint shall be applied by a brush, roller or spray. Materials when brushed shall be evenly flowed on with brushes best suited for the type of material being applied. When using a roller, covers shall be of a type most suited for approved materials and textures. Spray applied paint shall be uniformly applied under pressure using recommended equipment.
- D. Apply paint to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks. Where applicable due to project conditions blend in with previously painted surfaces not indicated to receive new finishes.
  1. Finished surfaces shall have uniform color, dry opacity, and sheen.

### **3.5 CLEANING AND PROTECTION**

- A. Protect work of other trades, whether being painted or not, against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, and leave in an undamaged condition.
- B. Provide "Wet Paint" signs to warn occupants of and to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.
- C. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.
- D. At the end of each work day, remove empty cans, rags, cleaning pads, rubbish, and other discarded paint materials from the site.
- E. Just prior to final completion and acceptance, the Contractor shall examine painted and refinished surfaces and retouch or refinish as necessary and required to leave surfaces in perfect condition.
- F. Upon completion of work, painting contractor shall remove paint and varnish spots from floors and other surfaces and remove rubbish and accumulated materials of whatever nature not caused by other trades from premises and leave work in a clean, orderly and acceptable condition. Clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping. Be careful not to scratch or damage adjacent finished surfaces or to generate dust.

### **3.6 SCHEDULE OF PAINTING**

- A. Products listed on the SCHEDULE OF PAINTING have been recommended by the paint system manufacturers for the intended use and establish a level of quality. If the Contractor submits and/or uses the specified products, the Contractor agrees that the specified products are proper for the intended use. If the Contractor does not agree with

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the use of the specified products, and recommends the use of alternative products that meet or exceed the level of quality of the specified products, the Contractor shall submit written explanation and supporting data from the manufacturer for the proposed products. Only products confirmed in writing by the paint manufacturer that meet or exceed the level of quality of the specified products will be considered. If accepted, proposed products shall be covered under the provisions of the warranty.

- B. Painting and finishing to new and existing surfaces shall be done in accordance with the following schedule except as otherwise noted herein.
1. Prior to application of finishes, perform proper cleaning and preparatory work, moisture/alkalinity/adhesion testing, etc. to all surfaces to be painted/coated as specified within this section. The application of paint or finishes shall be an indication of the Contractor's acceptance of the surface.
  2. Paint exposed surfaces unless noted otherwise. Exposed surfaces include areas visible when permanent or built-in fixtures, convector covers, covers for finned-tube radiation, grilles, and similar components are in place. Extend coatings in these areas, as required, to maintain the system integrity and provide desired protection.
  3. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before the final installation of permanently fixed equipment or furniture, paint surfaces behind such equipment or furniture with prime coat only.
  4. Paint interior surfaces of ducts with a flat, non-specular black paint where visible through registers or grilles.
  5. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.
  6. Paint access panels, electrical panels, air diffusing outlets, supply and exhaust grilles, louvers, exposed conduit, primed hardware items, primed outlet covers, primed wall and ceiling plates and other items in painted areas to match the areas in which they occur unless otherwise directed by the Architect.
  7. Finish doors on tops, bottoms, and side edges the same as exterior faces.
  8. Sand lightly using low-dust emission wet methods between each succeeding enamel or varnish coat, and any other coating products meeting manufacturer's requirements.
  9. Do not paint prefinished surfaces.
- C. It is the intent that the indicated enumeration of coats on surfaces will give approved coverage coatings and each coat shall be applied heavy enough to obtain this result or additional coat(s) will be required at no additional cost. Finished surfaces shall have uniform color, dry opacity, and sheen.
- D. The indicated enumeration of coats is the minimum acceptable number of each item. Substitution of one heavy coat is not an acceptable substitution for two coats.
1. Each coat at a minimum must achieve the manufacturers recommended minimum dry film thickness for the specified item.
- E. Abbreviations shown are:
1. S-W = Sherwin-Williams
  2. PPG = PPG Paints

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F. Exterior Painting

1. Non-ferrous and galvanized metal, except pre-finished metal work, but including stacks, flues, vents, vent enclosures, fan enclosures, etc. on roof regardless of metal type; eggshell sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, Pro Cryl Metal Primer B66-310
    2. PPG, Pitt-Tech DTM Primer 90-712
  - b. First and Second Finish Coats
    1. S-W, Pro Industrial Zero VOC Acrylic B66 Series
    2. PPG, Pitt-Tech DTM Finish 90-374
  - c. Notes:
    1. At flues and vents subject to high temperatures, in lieu of above provide manufacturer's high temperature resistant primer coat and finish coats to assure a proper, stable coating.
    2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
    3. Provide specified TSP cleaning to existing surfaces to remove dirt, grease, etc. before painting.
2. Galvanized ferrous metal including railings, guardrail assemblies, pipe bumpers, and wall mounted ladders; gloss sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, Pro Cryl Metal Primer B66-310
    2. PPG, Pitt-Tech DTM Primer 90-712
  - b. First and Second Finish Coats
    1. S-W, Pro Industrial Urethane Enamel B54 Series
    2. PPG, Glyptex Urethane Enamel PP4139
  - c. Notes:
  - d. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
3. Ferrous metal, including but not limited to metal doors and frames; gloss sheen finish, 2 finish coats over shop primer coats:
  - a. First and Second Finish Coats
    1. S-W, Pro Industrial Urethane Enamel B54 Series
    2. PPG, Glyptex Urethane Enamel PP4139
  - b. Notes:

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1. Bare metal surfaces shall be touched up with manufacturers required primer before painting, confirm compatibility with shop primer coats
    - a. S-W, DTM Primer B66W1
    - b. PPG, Pitt-Tech DTM Primer 90-712
  2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
4. Exposed structural steel, steel lintels, pipe bollards, railings and guardrails, metal doors and frames, wall mounted ladders, entrance skylight canopies including columns, plates, etc.; gloss sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, Macropoxy 646 Fast Cure Epoxy B58 Series
    2. PPG, Amerlock 2 Epoxy
  - b. First and Second Finish Coats
    1. S-W, Acrolon 218 HS Acrylic Polyurethane B65 Series
    2. PPG, Amercoat 450H Polyurethane
  - c. Notes:
    1. Clean surfaces prior to application of finishes with:
      - a. S-W, Great Lakes Lab Extra Muscle Prepaint Cleaner
      - b. PPG, Dura Prep 120 Cleaner
    2. Galvanized surfaces to receive manufacturers required preparatory methods including any required barrier coats.
    3. Shop primed or existing painted surfaces to receive a barrier coat prior to application of Primer Coat:
      - a. S-W, ProIndustrial ProCryl Metal Primer
      - b. PPG, the specified Amerlock 2 Epoxy primer is a "surface tolerant" epoxy mastic that does not require a separate barrier coat over shop primed steel.
5. Precast concrete wall panels, concrete, and CMU; flat sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, Loxon Primer A24 series for Concrete and Masonry
    2. PPG, Permacrete 4-100 Concrete Block and Masonry Filler
  - b. First and Second Finish Coats
    1. S-W, Loxon XP A24 series
    2. PPG, Permacrete 4-22 100% Acrylic Coating
  - c. Notes:

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1. System to be installed per manufacturers requirements for a pure acrylic water-repellant coating system
  2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
  3. Existing painted surfaces to be media blasted to remove paint down to bare concrete.
  4. Provide specified TSP cleaning to existing surfaces to remove dirt, grease, etc. before painting.
6. Exposed surfaces of concrete, and non-textured GFRC to receive textured acrylic elastomeric field applied coating system; flat sheen, fine sand texture finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. PPG, Permacrete 4-2 High Build Acrylic Primer
    2. Dryvit Systems, Inc., Weatherprime Acrylic Primer
  - b. First and Second Finish Coats
    1. PPG, Permacrete 4-50 Texture Coatings Fine
    2. Dryvit Systems, Inc., Weatherlastic Sandpebble Fine
  - c. Note:
    1. System to be installed only after surface imperfections have been corrected, cracks have been treated, and proper preparatory work has been completed per manufacturer's requirements.
7. Finished wood trim, fascia, soffits, sills, siding, fencing, trash enclosures, etc.; Semi-Transparent Stain, 2 finish coats:
  - a. First and Second Finish Coats
    1. S-W, Woodscapes Semi-Transparent Exterior Stain
    2. PPG, Flood Pro Series, Semi-Transparent Stain, Acrylic/Oil
8. Finished wood trim, fascia, soffits, sills, siding, fencing, trash enclosures, etc.; Opaque Stain, 2 finish coats:
  - a. First and Second Finish Coats
    1. S-W, Woodscapes Solid Color Exterior Stain
    2. PPG, Flood Pro Series, Solid Color Stain, 100% Acrylic Latex
- G. Interior Painting
  1. Exposed ferrous metal work including but not limited to steel lintels, pipe bollards, railings and guardrails, metal doors and frames; semi-gloss sheen finish, 2 finish coats over shop primer coats:
    - a. First and Second Finish Coats
      1. S-W, ProMar 200 Interior Latex Acrylic-Alkyd B34W08251



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2. PPG, Speedhide WB Alkyd 6-1510
- b. Notes:
  1. Bare metal surfaces shall be touched up with manufacturers required primer before painting, confirm compatibility with shop primer coats
    - a. S-W, ProCryl Universal Metal Primer
    - b. PPG, Seal Grip 17-921 Acrylic Primer
  2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
2. Metal work not primed; semi-gloss sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, ProCryl Universal Metal Primer
    2. PPG, Seal Grip 17-921 Acrylic Primer
  - b. First and Second Finish Coats
    1. S-W, ProMar 200 Interior Latex Acrylic-Alkyd B34W08251
    2. PPG, Speedhide WB Alkyd 6-1510
3. Structural steel, including associated plates, brackets, etc., steel joists, bulb tees, metal floor and roof deck; semi-gloss sheen finish, 2 finish coats over shop primer coats:
  - a. First and Second Finish Coats
    1. S-W, ProMar 200 Interior Latex Acrylic-Alkyd B34W08251
    2. PPG, Speedhide WB Alkyd 6-1510
  - b. Notes:
    1. Bare metal surfaces shall be touched up with manufacturers required primer before painting, confirm compatibility with shop primer coats
      - a. S-W, ProCryl Universal Metal Primer
      - b. PPG, Seal Grip 17-921 Acrylic Primer
    2. At galvanized metal surfaces provide manufacturer's required Primer Coat before applying the 2 finish coats
      - a. S-W, DTM Primer B66W1.
      - b. PPG, Pitt-Tech DTM Primer 90-712
    3. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
4. Concrete block surfaces; semi-gloss sheen finish, 2 finish coats over 1 primer coat:

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- a. Primer Coat
    - 1. S-W, Interior/Exterior Latex Block Filler
    - 2. PPG, Speedhide Block Filler 6-7
  - b. First and Second Finish Coats
    - 1. S-W, ProMar 200 Interior Latex Acrylic-Alkyd, B34W08251
    - 2. PPG, Speedhide WB Alkyd 6-1510
  - c. Notes:
    - 1. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
5. Concrete block surfaces indicated to receive epoxy wall coating; semi-gloss sheen finish, 2 finish coats over 1 primer coat:
- a. Primer Coat
    - 1. S-W, Heavy Duty Block Filler B42W46
    - 2. PPG, Speedhide Block Filler 6-7
  - b. First and Second Finish Coats
    - 1. S-W, Pro Industrial Pre-Catalyzed Waterbased Epoxy K46-150
    - 2. PPG, Pitt-Glaze WB1 Pre-Catalyzed Water-Borne Acrylic Epoxy 16-510
  - c. Notes:
    - 1. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
6. Concrete block surfaces, indicated to receive epoxy wall coating; gloss sheen finish, 2 finish coats over 1 primer coat:
- a. Primer Coat
    - 1. S-W, Heavy Duty Block Filler B42W46
    - 2. PPG, Speedhide Block Filler 6-7
  - b. First and Second Finish Coats
    - 1. S-W, Pro Industrial Water Based Catalyzed Epoxy B73 Series
    - 2. PPG, Aquapon WB Water Base Epoxy 98-101 Series
  - c. Notes:
    - 1. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
7. Gypsum board, impact resistant cement board, plaster, acoustic diffuser ceiling and wall panels, spandrel panels, MDF panels, wood trim indicated to be painted, etc.: finish sheen as noted, 2 finish coats over 1 primer coat:

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- a. Primer Coat
    - 1. S-W, ProMar 200 Zero VOC Interior Latex Primer B28W2600
    - 2. PPG, Speedhide Zero VOC Interior Latex Primer 6-4900xi
  - b. First and Second Finish Coats
    - 1. S-W, ProMar 200 Zero VOC Interior Latex B20W12651 / B30W02651
    - 2. PPG, Speedhide Zero VOC Interior Latex 6-4340xi / 6-4110xi
  - c. Notes:
    - 1. Walls and trim to have eggshell sheen finish, ceilings and soffits to have flat sheen finish.
    - 2. MDF panels to have coatings spray applied to achieve the desired results.
    - 3. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
8. Gypsum board surfaces indicated to receive epoxy wall coating; eggshell sheen finish, 2 finish coats over 1 primer coat:
- a. Primer Coat
    - 1. S-W, ProMar 200 Zero VOC Wall Primer B28W2600
    - 2. PPG, Speedhide Zero VOC Primer 6-4900xi
  - b. First and Second Finish Coats
  - c. First and Second Finish Coats
    - 1. S-W, Pro Industrial Pre-Catalyzed Waterbased Epoxy K45-150
    - 2. PPG, Pitt-Glaze WB1 Pre-Catalyzed Water-Borne Acrylic Epoxy 16-310
  - d. Notes:
    - 1. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
9. Faces and edges of wood base, trim, field finished wood doors, etc., to receive stain finish; satin top coat sheen finish, 3 finish coats over 1 stain coat:
- a. Stain Coat
    - 1. S-W, Wood Classics 250 Oil Stain A49 Series
    - 2. PPG, Deft Oil Based Stain DFT 400
  - b. First and Second Finish Coats, and Third Finish Top Coat (Satin)
    - 1. S-W, Wood Classics WB Poly Satin
    - 2. PPG, Deft WB Poly Satin DFT 157
  - c. Notes:

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1. Sand lightly between finish coats per manufacturers requirements.
10. Insulation covering of exposed piping in finished areas; flat sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, ProMar 200 Zero VOC Interior Latex Primer B28W2600
    2. PPG, Speedhide Zero VOC Interior Latex Primer 6-4900xi
  - b. First and Second Finish Coats
    1. S-W, ProMar 200 Zero VOC Interior Latex B30W02651
    2. PPG, Speedhide Zero VOC Interior Latex 6-4110xi
  - c. Notes:
    1. Verify and coordinate compatibility of finish materials with insulation covering materials and provide necessary products for a complete and proper finish.
    2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
11. Exposed uncovered piping, electrical conduit, wire mold, gas lines, unfinished radiation and heating units, in finished areas; low sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, ProCryl Universal Metal Primer
    2. PPG, Seal Grip 17-921 Acrylic Primer
  - b. First and Second Finish Coats
    1. S-W, ProMar 200 Interior Latex Acrylic-Alkyd B33W08251
    2. PPG, Speedhide WB Alkyd 6-1410
  - c. Notes:
    1. At galvanized metal surfaces provide manufacturer's required Primer Coat before applying the 2 finish coats
      - a. S-W, DTM Primer B66W1
      - b. PPG, Pitt-Tech Plus DTM Primer 90-912
    2. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.
12. Exposed galvanized sheet metal, including ductwork, in finished areas; flat sheen finish, 2 finish coats over 1 primer coat:
  - a. Primer Coat
    1. S-W, DTM Primer B66W1
    2. PPG, Pitt-Tech Plus DTM Primer 90-712

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- b. First and Second Finish Coats
  - 1. S-W, ProMar 200 Zero VOC Interior Latex B30W02651
  - 2. PPG, Speedhide Zero VOC Interior Latex 6-4110xi
- c. Notes:
  - 1. At existing painted surfaces after proper preparatory work has occurred provide manufacturer's proper Primer Coat compatible with existing surfaces before applying the 2 finish coats.

**END OF SECTION 09 9100**



**SECTION 22 0517**

**SLEEVES AND SLEEVE SEALS FOR PLUMBING 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. Sleeves.
  - 2. Stack-sleeve fittings.
  - 3. Sleeve-seal systems.
  - 4. Sleeve-seal fittings.
  - 5. Grout.

**1.3 ACTION SUBMITTALS**

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

**PART 2 - PRODUCTS**

**2.1 SLEEVES**

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

**2.2 STACK-SLEEVE FITTINGS**

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

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

## **2.3 SLEEVE-SEAL SYSTEMS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advance Products & Systems, Inc.
  - 2. CALPICO, Inc.
  - 3. Metraflex Company (The).
  - 4. Pipeline Seal and Insulator, Inc.
  - 5. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Carbon steel.
  - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

## **2.4 SLEEVE-SEAL FITTINGS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Presealed Systems.
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

## **2.5 GROUT**

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

# **PART 3 - EXECUTION**

## **3.1 SLEEVE INSTALLATION**

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.



- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
  - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
  - 2. Cut sleeves to length for mounting flush with both surfaces.
    - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
  - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
  - 1. Cut sleeves to length for mounting flush with both surfaces.
  - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
  - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 9200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

### **3.2 STACK-SLEEVE-FITTING INSTALLATION**

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
  - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
  - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
  - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
  - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
  - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

### **3.3 SLEEVE-SEAL-SYSTEM INSTALLATION**

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and

sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

### **3.4 SLEEVE-SEAL-FITTING INSTALLATION**

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

### **3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE**

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

**END OF SECTION 22 0517**

**SECTION 22 0518**

**ESCUTCHEONS FOR PLUMBING 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. Escutcheons.
  - 2. Floor plates.

**1.3 ACTION SUBMITTALS**

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

**PART 2 - PRODUCTS**

**2.1 ESCUTCHEONS**

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

**2.2 FLOOR PLATES**

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

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
  - 1. Escutcheons for New Piping:
    - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- C. Install floor plates for piping penetrations of equipment-room floors.

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

### **3.2 FIELD QUALITY CONTROL**

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

**END OF SECTION 22 0518**

**SECTION 22 0519**

**METERS AND GAGES FOR PLUMBING 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. Bimetallic-actuated thermometers.
  - 2. Filled-system thermometers.
  - 3. Liquid-in-glass thermometers.
  - 4. Light-activated thermometers.
  - 5. Thermowells.
  - 6. Dial-type pressure gages.
  - 7. Gage attachments.
  - 8. Test plugs.
  - 9. Test-plug kits.
  - 10. Sight flow indicators.

**1.3 ACTION SUBMITTALS**

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

**1.4 INFORMATIONAL SUBMITTALS**

- A. Product Certificates: For each type of meter and gage, from manufacturer.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

**PART 2 - PRODUCTS**

**2.1 BIMETALLIC-ACTUATED THERMOMETERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ashcroft Inc.

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2. Ernst Flow Industries.
  3. Marsh Bellofram.
  4. Miljoco Corporation.
  5. Nanmac Corporation.
  6. Noshok.
  7. Palmer Wahl Instrumentation Group.
  8. REOTEMP Instrument Corporation.
  9. Tel-Tru Manufacturing Company.
  10. Trelice, H. O. Co.
  11. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  12. Weiss Instruments, Inc.
  13. WIKA Instrument Corporation - USA.
  14. Winters Instruments - U.S.
- B. Standard: ASME B40.200.
- C. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
- E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- H. Window: Plain glass.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 percent of scale range.

## **2.2 LIQUID-IN-GLASS THERMOMETERS**

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Flo Fab Inc.
    - b. Miljoco Corporation.
    - c. Palmer Wahl Instrumentation Group.
    - d. Tel-Tru Manufacturing Company.
    - e. Trelice, H. O. Co.
    - f. Weiss Instruments, Inc.
    - g. Winters Instruments - U.S.
  2. Standard: ASME B40.200.
  3. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
  4. Case Form: Adjustable angle unless otherwise indicated.
  5. Tube: Glass with magnifying lens and blue organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Aluminum 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.

## 2.3 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 or CUNI.
  4. Material for Use with Steel Piping: CRES CSA.
  5. Type: Stepped shank unless straight or tapered shank is indicated.
  6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, 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.

## 2.4 PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AMETEK, Inc.; U.S. Gauge.
    - b. Ashcroft Inc.
    - c. Ernst Flow Industries.
    - d. Flo Fab Inc.
    - e. Marsh Bellofram.
    - f. Miljoco Corporation.
    - g. Noshok.
    - h. Palmer Wahl Instrumentation Group.
    - i. REOTEMP Instrument Corporation.
    - j. Tel-Tru Manufacturing Company.
    - k. Trerice, H. O. Co.
    - l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
    - m. Weiss Instruments, Inc.
    - n. WIKA Instrument Corporation - USA.
    - o. Winters Instruments - U.S.
  2. Standard: ASME B40.100.
  3. Case: Liquid-filled Solid-front, pressure relief; cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
  4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
  5. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
  6. Movement: Mechanical, with link to pressure element and connection to pointer.
  7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.

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8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

## **2.5 GAGE ATTACHMENTS**

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

## **2.6 TEST PLUGS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Flow Design, Inc.
  2. Miljoco Corporation.
  3. National Meter, Inc.
  4. Peterson Equipment Co., Inc.
  5. Sisco Manufacturing Company, Inc.
  6. Trerice, H. O. Co.
  7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  8. 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 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

## **2.7 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. National Meter, Inc.
  4. Peterson Equipment Co., Inc.
  5. Sisco Manufacturing Company, Inc.
  6. Trerice, H. O. Co.
  7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
  8. Weiss Instruments, Inc.



- B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, 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 deg 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 deg F.
- E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- F. Carrying Case: Metal or plastic, with formed instrument padding.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install thermowells with socket extending a minimum of 2 inches into fluid 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 remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install test plugs in piping tees.
- K. Install thermometers in the following locations:
  - 1. Inlet and outlet of each water heater.
  - 2. Inlet and outlet of each domestic hot-water storage tank.
- L. Install pressure gages in the following locations:
  - 1. Building water service entrance into building.
  - 2. Inlet and outlet of each pressure-reducing valve.
  - 3. Suction and discharge of each domestic water pump.

### **3.2 CONNECTIONS**

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

### **3.3 ADJUSTING**

- A. Adjust faces of meters and gages to proper angle for best visibility.

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

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.
- B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F.

### **3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE**

- A. Scale Range for Water Service Piping: 0 to 160 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.

**END OF SECTION 22 0519**

**SECTION 22 0523.12**

**BALL VALVES FOR PLUMBING 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. Brass ball valves.
  - 2. Bronze ball valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of valve.
  - 1. Certification that products comply with NSF 61 and NSF 372.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, and soldered ends.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
- 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 operating handles or stems as lifting or rigging points.

## **PART 2 - PRODUCTS**

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

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B1.20.1 for threads for threaded end valves.
  - 2. ASME B16.1 for flanges on iron valves.
  - 3. ASME B16.5 for flanges on steel valves.
  - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 5. ASME B16.18 for solder-joint connections.
  - 6. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
  - 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
  - 2. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
  - 1. Include 2-inch stem extensions.
  - 2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
  - 3. Memory stops that are fully adjustable after insulation is applied.

### **2.2 BRASS BALL VALVES**

- A. Two-Piece, Brass Ball Valves with Full Port and Stainless-Steel Trim:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Kitz Corporation.
    - b. Marwin Valve; a division of Richards Industries.
    - c. Milwaukee Valve Company.
  - 2. Description:
    - a. Standard: MSS SP-110.
    - b. CWP Rating: 600 psig.
    - c. Body Design: Two piece.
    - d. Body Material: Forged brass.
    - e. Ends: Threaded and soldered.
    - f. Seats: PTFE.

- g. Stem: Stainless steel.
- h. Ball: Stainless steel, vented.
- i. Port: Full.

## **2.3 BRONZE BALL VALVES**

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

## **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 valve tags. Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

### **3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
  - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

### **3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE**

- A. Valves shall be:
  - 1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
  - 2. Two-piece, brass ball valves with full port and stainless-steel trim.

**END OF SECTION 22 0523.12**

**SECTION 22 0523.14**

**CHECK VALVES FOR PLUMBING 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. Bronze lift check valves.
  - 2. Bronze swing check valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of valve.
  - 1. Certification that products comply with NSF 61 and NSF 372.

**1.5 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 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. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B1.20.1 for threads for threaded end valves.
  - 2. ASME B16.1 for flanges on iron valves.
  - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  - 4. ASME B16.18 for solder joint.
  - 5. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Bypass and Drain Connections: MSS SP-45.

### **2.2 BRONZE LIFT CHECK VALVES**

- A. Class 125, Lift Check Valves with Nonmetallic Disc:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Flo Fab Inc.
    - b. Hammond Valve.
    - c. Kitz Corporation.
    - d. Milwaukee Valve Company.
    - e. Mueller Steam Specialty; a division of SPX Corporation.
    - 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-80, Type 2.
    - b. CWP Rating: 200 psig.
    - c. Body Design: Vertical flow.
    - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
    - e. Ends: Threaded or soldered. See valve schedule articles.
    - f. Disc: NBR, PTFE.



## **2.3 BRONZE SWING CHECK VALVES**

- A. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by 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 Valves.
    - d. Hammond Valve.
    - e. Kitz Corporation.
    - 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 4.
    - b. CWP Rating: 200 psig.
    - c. Body Design: Horizontal flow.
    - d. Body Material: ASTM B 62, bronze.
    - e. Ends: Threaded or soldered. See valve schedule articles.
    - f. Disc: PTFE.
- B. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Crane Co.; Crane Valve Group; Crane Valves.
    - b. Crane Co.; Crane Valve Group; Jenkins 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-80, Type 4.
    - b. CWP Rating: 300 psig.
    - c. Body Design: Horizontal flow.
    - d. Body Material: ASTM B 62, bronze.
    - e. Ends: Threaded or soldered. See valve schedule articles.
    - f. Disc: PTFE.

## **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.
  - 2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
  - 3. Lift Check Valves: With stem upright and plumb.
- F. Install valve tags. Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

### **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. Pump-Discharge Check Valves:
    - a. NPS 2 and Smaller: Bronze swing check valves with nonmetallic disc.
    - b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; or iron, center-guided, resilient-seat check valves.
    - c. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. End Connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered.
  - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded.
  - 3. For Copper Tubing, NPS 5 and Larger: Flanged.

4. For Steel Piping, NPS 2 and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged or threaded.
6. For Steel Piping, NPS 5 and Larger: Flanged.

### **3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller: Bronze swing check valves, Class 125, nonmetallic disc with soldered or threaded end connections.
- B. Pipe NPS 2-1/2 and Larger:
  1. Iron swing check valves, Class 125, nonmetallic-to-metal seats with threaded or flanged end connections.

**END OF SECTION 22 0523.14**



**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. Section Includes:
  - 1. Metal 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 of The Valve and Fittings Industry Inc.

**1.4 QUALITY ASSURANCE**

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

**PART 2 - PRODUCTS**

**2.1 METAL PIPE HANGERS AND SUPPORTS**

- A. Carbon-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
  - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.

4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel>.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

## 2.2 TRAPEZE PIPE HANGERS

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

## 2.3 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. ERICO International Corporation.
  2. National Pipe Hanger Corporation.
  3. Pipe Shields Inc.
  4. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- 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.

## 2.4 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.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

## **2.5 PIPE STANDS**

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece [plastic] [stainless-steel] base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
  - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
  - 2. Base: [Plastic] [Stainless steel].
  - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
  - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
  - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
  - 2. Bases: One or more; plastic.
  - 3. Vertical Members: Two or more protective-coated-steel channels.
  - 4. Horizontal Member: Protective-coated-steel channel.
  - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

## **2.6 PIPE POSITIONING SYSTEMS**

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

## **2.7 EQUIPMENT SUPPORTS**

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

## **2.8 MISCELLANEOUS MATERIALS**

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

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

## **PART 3 - EXECUTION**

### **3.1 HANGER AND SUPPORT INSTALLATION**

- A. Metal 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 the building structure.
- B. Metal 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 for individual pipe hangers.
  - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- 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-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
  - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 7200 "Roof Accessories" for curbs.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.



- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
  - 1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
  - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
  - 4. Shield Dimensions for Pipe: Not less than the following:
    - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    - b. NPS 4: 12 inches long and 0.06 inch thick.
    - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
    - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
  - 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
  - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

### **3.2 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 bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

### **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/D1.1M 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 so 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. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09 9123 "Interior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

### 3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and support or metal trapeze pipe hangers and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
  - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, 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 36, requiring clamp flexibility and up to 4 inches of insulation.
  - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
  - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
  - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
  - 7. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
  - 8. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
  - 9. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
  - 10. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
  - 11. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
  - 12. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

13. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
  14. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
  15. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
  16. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
  17. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
  18. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- J. 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 24.
  2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
  3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
  4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
  2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
  3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  6. C-Clamps (MSS Type 23): For structural shapes.
  7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
  9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    - a. Light (MSS Type 31): 750 lb.
    - b. Medium (MSS Type 32): 1500 lb.
    - c. Heavy (MSS Type 33): 3000 lb.
  13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
  15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. 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.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
  2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
  3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
  4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
  5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
  6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
  7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
  8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    - a. Horizontal (MSS Type 54): Mounted horizontally.
    - b. Vertical (MSS Type 55): Mounted vertically.
    - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

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- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

**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. Equipment labels.
  - 2. Pipe labels.
  - 3. Valve tags.

**1.3 ACTION 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 EQUIPMENT LABELS**

- A. Metal Labels for Equipment:

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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 for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  4. Fasteners: Stainless-steel rivets or self-tapping screws.
  5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
  2. Letter Color: Black.
  3. Background Color: Yellow.
  4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
  5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
  6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  7. Fasteners: Stainless-steel rivets or self-tapping screws.
  8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

## 2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
  2. Lettering Size: At least 1-1/2 incheshigh.



### **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: 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 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 surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

### **3.2 EQUIPMENT LABEL INSTALLATION**

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### **3.3 PIPE LABEL INSTALLATION**

- A. Piping Color-Coding: Painting of piping is specified in Section 09 9123 "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. Domestic Water Piping:

- a. Background Color: Blue.
  - b. Letter Color: Black.
- 2. Sanitary Waste Piping:
  - a. Background Color: Orange.
  - 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; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
  - 1. Valve-Tag Size and Shape:
    - a. Cold Water: 2 inches, round.
    - b. Hot Water: 2 inches, round.
  - 2. Valve-Tag Color:
    - a. Cold Water: Green.
    - b. Hot Water: Green.
  - 3. Letter Color:
    - a. Cold Water: Black.
    - b. Hot Water: Black.

**END OF SECTION 22 0553**

**SECTION 22 0719**

**PLUMBING PIPING INSULATION**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section includes insulating the following plumbing piping services:
  - 1. Domestic cold-water piping.
  - 2. Domestic hot-water piping.
  - 3. Domestic recirculating hot-water piping.
  - 4. Storm-water piping exposed to freezing conditions.
  - 5. Roof drains and rainwater leaders.
  - 6. Supplies and drains for handicap-accessible lavatories and sinks.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail insulation application at pipe expansion joints for each type of insulation.
  - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
  - 6. Detail application of field-applied jackets.
  - 7. Detail application at linkages of control devices.

**1.4 INFORMATIONAL SUBMITTALS**

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

- C. Field quality-control reports.

## **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
  - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

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

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

## **1.7 COORDINATION**

- A. Coordinate sizes and locations of supports, hangers, and insulation shields.
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

## **1.8 SCHEDULING**

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

## **PART 2 - PRODUCTS**

### **2.1 INSULATION MATERIALS**

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come 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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Pittsburgh Corning Corporation; Foamglas.
  - 2. Block Insulation: ASTM C 552, Type I.
  - 3. Special-Shaped Insulation: ASTM C 552, Type III.
  - 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
  - 5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
  - 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- F. Mineral-Fiber, Preformed Pipe Insulation:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Fibrex Insulations Inc.; Coreplus 1200.
    - b. Johns Manville; Micro-Lok.
    - c. Knauf Insulation; 1000-Degree Pipe Insulation.
    - d. Manson Insulation Inc.; Alley-K.
    - e. Owens Corning; Fiberglas Pipe Insulation.
  - 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

### **2.2 INSULATING CEMENTS**

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
  - 1. Products: Subject to compliance with requirements, provide the following:

- a. Ramco Insulation, Inc.; Super-Stik.

## 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
  - 1. Products: Subject to compliance with requirements, provide the following:
    - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    - b. Eagle Bridges - Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. ASJ Adhesive, and FSK Jacket 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 one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    - b. Eagle Bridges - Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
    - d. Mon-Eco Industries, Inc.; 22-25.
  - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Dow Corning Corporation; 739, Dow Silicone.
  - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
  - c. P.I.C. Plastics, Inc.; Welding Adhesive.
  - d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.4 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass: Subject to compliance with requirements, provide one of the following:
  - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
  - b. Eagle Bridges - Marathon Industries; 405.
  - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
  - d. Mon-Eco Industries, Inc.; 44-05.
  - e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
  - b. Eagle Bridges - Marathon Industries; 405.
  - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.

- d. Mon-Eco Industries, Inc.; 44-05.
  - 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 deg F.
  - 5. Color: Aluminum.
  - 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
- 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 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 deg F.
    - 5. Color: White.
    - 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - 7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

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

## **2.6 TAPES**

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
- 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 428 AWF ASJ.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    - c. Compac Corporation; 104 and 105.
    - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.



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2. Width: 3 inches.
  3. Thickness: 11.5 mils.
  4. Adhesion: 90 ounces force/inch in width.
  5. Elongation: 2 percent.
  6. Tensile Strength: 40 lbf/inch in width.
  7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 491 AWF FSK.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    - c. Compac Corporation; 110 and 111.
    - d. Venture Tape; 1525 CW NT, 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.
- C. 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 one of the following:
    - a. ABI, Ideal Tape Division; 370 White PVC tape.
    - b. Compac Corporation; 130.
    - c. 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.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ABI, Ideal Tape Division; 488 AWF.
    - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    - c. Compac Corporation; 120.
    - 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.

## **2.7 SECUREMENTS**

- A. Bands:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. ITW Insulation Systems; Gerrard Strapping and Seals.
    - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
  - 2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

## **2.8 PROTECTIVE SHIELDING GUARDS**

- A. Protective Shielding Pipe Covers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Engineered Brass Company.
    - b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
    - c. McGuire Manufacturing.
    - d. Plumberex.
    - e. Truebro; a brand of IPS Corporation.
    - f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
  - 2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 PREPARATION**

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

- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
  - 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.3 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 item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers and around anchor attachments.
  - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
  1. Draw jacket tight and smooth.
  2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below-ambient services, apply vapor-barrier mastic over staples.
  4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
  1. Vibration-control devices.
  2. Testing agency labels and stamps.
  3. Nameplates and data plates.
  4. Cleanouts.

### **3.4 PENETRATIONS**

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  1. Seal penetrations with flashing sealant.
  2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
  4. Seal jacket to roof flashing with flashing sealant.

- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
  - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
  - 1. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
  - 1. Pipe: Install insulation continuously through floor penetrations.
  - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

### **3.5 GENERAL PIPE INSULATION INSTALLATION**

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
  - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
  - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
  - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
  - 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve

- stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
  6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
  7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
  8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
  9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
  2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
  3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
  4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
  5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

### **3.6 INSTALLATION OF CELLULAR-GLASS INSULATION**

- A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

### 3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

### 3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
  - a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

### 3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:



1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.10 PIPING INSULATION SCHEDULE, GENERAL**

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
  2. Underground piping.
  3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

### **3.11 INDOOR PIPING INSULATION SCHEDULE**

- A. Domestic Supply Water:
1. Insulation shall be the following:
    - a. Cellular Glass: 1 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- B. Stormwater and Overflow:
1. All Pipe Sizes: Insulation shall be the following:
    - a. Cellular Glass: 1 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- C. Roof Drain and Overflow Drain Bodies:
1. All Pipe Sizes: Insulation shall be the following:
    - a. Cellular Glass: 1 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
1. All Pipe Sizes: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

- E. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Cellular Glass: 1 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

**3.12 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET**

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

**END OF SECTION 22 0719**

**SECTION 22 1116**

**DOMESTIC WATER 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. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For transition fittings and dielectric fittings.

**1.4 INFORMATIONAL SUBMITTALS**

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

**PART 2 - PRODUCTS**

**2.1 PIPING MATERIALS**

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

**2.2 COPPER TUBE AND FITTINGS**

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

- D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- E. Copper Unions:
  - 1. MSS SP-123.
  - 2. Cast-copper-alloy, hexagonal-stock body.
  - 3. Ball-and-socket, metal-to-metal seating surfaces.
  - 4. Solder-joint or threaded ends.

## **2.3 PIPING JOINING MATERIALS**

- A. Pipe-Flange Gasket Materials:
  - 1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
  - 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

## **2.4 TRANSITION FITTINGS**

- A. General Requirements:
  - 1. Same size as pipes to be joined.
  - 2. Pressure rating at least equal to pipes to be joined.
  - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Coupling: AWWA C219.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Cascade Waterworks Manufacturing.
    - b. Dresser, Inc.; Piping Specialties Products.
    - c. Ford Meter Box Company, Inc. (The).
    - d. JCM Industries.
    - e. Romac Industries, Inc.
    - f. Smith-Blair, Inc.; a Sensus company.
    - g. Viking Johnson.

## **2.5 DIELECTRIC FITTINGS**

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

- B. Dielectric Unions:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company; member of the Phoenix Forge Group.
    - b. Central Plastics Company.
    - c. Hart Industries International, Inc.
    - d. Jomar International.
    - e. Matco-Norca.
    - f. McDonald, A. Y. Mfg. Co.
    - g. Watts; a division of Watts Water Technologies, Inc.
    - h. Wilkins; a Zurn company.
  - 2. Standard: ASSE 1079.
  - 3. Pressure Rating: 150 psig.
  - 4. End Connections: Solder-joint copper alloy and threaded ferrous.

### **PART 3 - EXECUTION**

#### **3.1 EARTHWORK**

- A. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

#### **3.2 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 0519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 22 1119 "Domestic Water Piping Specialties."
- E. Install shutoff valve immediately upstream of each dielectric fitting.
- F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 1119 "Domestic Water Piping Specialties."
- G. Install domestic water piping level without pitch and plumb.
- H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

- I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- J. 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.
- K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- L. Install piping to permit valve servicing.
- M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- N. Install piping free of sags and bends.
- O. Install fittings for changes in direction and branch connections.
- P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- Q. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22 0519 "Meters and Gages for Plumbing Piping."
- R. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 1123 "Domestic Water Pumps."
- S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 0519 "Meters and Gages for Plumbing Piping."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 0518 "Escutcheons for Plumbing Piping."

### **3.3 JOINT CONSTRUCTION**

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
  2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Braze Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

### **3.4 TRANSITION FITTING INSTALLATION**

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
  2. Fittings for NPS 2 and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

### **3.5 DIELECTRIC FITTING INSTALLATION**

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

### **3.6 HANGER AND SUPPORT INSTALLATION**

- A. Comply with requirements for pipe hanger and shown below:
1. Vertical Piping: MSS Type 8 or 42, clamps.
  2. Individual, Straight, Horizontal Piping Runs:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
  3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
  2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
  3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.

4. NPS 2-1/2: 108 inches with 1/2-inch rod.
  5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
  6. NPS 6: 10 feet with 5/8-inch rod.
  7. NPS 8: 10 feet with 3/4-inch rod.
- E. Install supports for vertical copper tubing every 10 feet.
- F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
  2. NPS 1-1/2: 108 inches with 3/8-inch rod.
  3. NPS 2: 10 feet with 3/8-inch rod.
  4. NPS 2-1/2: 11 feet with 1/2-inch rod.
  5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
  6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
  7. NPS 6: 12 feet with 3/4-inch rod.
  8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.
- G. Install supports for vertical steel piping every 15 feet.
- H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

### **3.7 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
  2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
  3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
  4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

### **3.8 IDENTIFICATION**

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.



### **3.9 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Piping Inspections:
    - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
    - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
      - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
    - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
    - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
  - 2. Piping Tests:
    - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
    - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
    - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
    - d. 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 it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
    - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
    - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### **3.10 ADJUSTING**

- A. Perform the following adjustments before operation:
  - 1. Close drain valves, hydrants, and hose bibbs.
  - 2. Open shutoff valves to fully open position.
  - 3. Open throttling valves to proper setting.
  - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
    - a. Adjust calibrated balancing valves to flows indicated.
  - 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
  - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
  - 7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
  - 8. Check plumbing specialties and verify proper settings, adjustments, and operation.

### **3.11 CLEANING**

- A. Clean and disinfect potable domestic water piping as follows:
  - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
  - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
    - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    - b. Fill and isolate system according to either of the following:
      - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
    - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
    - d. Repeat procedures if biological examination shows contamination.
    - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

### **3.12 PIPING SCHEDULE**

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Domestic water piping shall be the following:
  - 1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.

### **3.13 VALVE SCHEDULE**

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
  - 1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
  - 2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
  - 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
  - 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- C. Iron grooved-end valves may be used with grooved-end piping.

**END OF SECTION 22 1116**

**SECTION 22 1119**

**DOMESTIC WATER PIPING SPECIALTIES**

**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. Balancing valves.
  - 2. Water-hammer arresters.
  - 3. Backflow preventers

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

**PART 2 - PRODUCTS**

**2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES**

- A. Potable-water piping and components shall comply with NSF 61. Mark "NSF-pw" on plastic piping components.

**2.2 PERFORMANCE REQUIREMENTS**

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

**2.3 BALANCING VALVES**

- A. Copper-Alloy Calibrated Balancing Valves:

1. Provide Taco Accu-Flo Series Calibrated balancing valves.
2. Type: Ball valve with two readout ports and memory-setting indicator.
3. Body: Brass.
4. Size: NPS 3/4.

## **2.4 WATER-HAMMER ARRESTERS**

### **A. Water-Hammer Arresters:**

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - a. AMTROL, Inc.
  - b. Josam Company.
  - c. MIFAB, Inc.
  - d. Precision Plumbing Products, Inc.
  - e. Sioux Chief Manufacturing Company, Inc.
  - f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
  - g. Tyler Pipe; Wade Div.
  - h. Watts Drainage Products.
  - i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

## **2.5 BACKFLOW PREVENTERS**

### **A. Beverage-Dispensing-Equipment Backflow Preventers:**

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - a. Conbraco Industries, Inc.
  - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
  - c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.

### **B. Dual-Check-Valve Backflow Preventers:**

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

- a. Cash Acme; a division of Reliance Worldwide Corporation.
    - b. Conbraco Industries, Inc.
    - c. FEBCO; a division of Watts Water Technologies, Inc.
    - d. Flomatic Corporation.
    - e. Ford Meter Box Company, Inc. (The).
    - f. Honeywell International Inc.
    - g. Legend Valve.
    - h. McDonald, A. Y. Mfg. Co.
    - i. Mueller Co. Ltd.; a subsidiary of Mueller Water Products Inc.
    - j. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
    - k. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
  2. Standard: ASSE 1024.
  3. Operation: Continuous-pressure applications.
  4. Size: NPS ½, or NPS 3/4.
  5. Body: Bronze with union inlet.
- C. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Cash Acme; a division of Reliance Worldwide Corporation.
    - b. Lancer Corporation.
    - c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
  2. Standard: ASSE 1032.
  3. Operation: Continuous-pressure applications.
  4. Size: NPS 1/4 or NPS 3/8.
  5. Body: Stainless steel.
  6. End Connections: Threaded.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install water-hammer arresters in water piping according to PDI-WH 201.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

### **3.2 ADJUSTING**

- A. Set field-adjustable flow set points of balancing valves.

**END OF SECTION 22 1119**



**SECTION 22 1316**

**SANITARY WASTE AND VENT 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. Pipe, tube, and fittings.
  - 2. Specialty pipe fittings.

**1.3 PERFORMANCE REQUIREMENTS**

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
  - 1. Soil, Waste, and Vent Piping: 10-foot head of water.
- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For solvent drainage system. Include plans, elevations, sections, and details.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.

**1.6 QUALITY ASSURANCE**

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

## **1.7 PROJECT CONDITIONS**

- A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - 1. Notify Architect, Construction Manager, and Owner no fewer than two weeks in advance of proposed interruption of sanitary waste service.
  - 2. Do not proceed with interruption of sanitary waste service without Architect's, Construction Manager's, and Owner's written permission.

## **PART 2 - PRODUCTS**

### **2.1 PIPING MATERIALS**

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

### **2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS**

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
- C. Heavy-Duty, Hubless-Piping Couplings:
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. ANACO-Husky.
    - b. Clamp-All Corp.
    - c. Dallas Specialty & Mfg. Co.
    - d. MIFAB, Inc.
    - e. Mission Rubber Company; a division of MCP Industries, Inc.
    - f. Stant.
    - g. Tyler Pipe.
  - 2. Standards: ASTM C 1277 and ASTM C 1540.
  - 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

### **2.3 PVC PIPE AND FITTINGS**

- A. Solid-Wall Schedule 40 PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.



- C. Adhesive Primer: ASTM F 656.
  - 1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. Solvent Cement: ASTM D 2564.
  - 1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

### **PART 3 - EXECUTION**

#### **3.1 EARTH MOVING**

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

#### **3.2 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not

change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- K. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
  - 1. Building Sanitary Drain: 2 percent downward in direction of flow..
  - 2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- L. Install aboveground PVC piping according to ASTM D 2665.
- M. Install underground PVC piping according to ASTM D 2321.
- N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
  - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- O. Plumbing Specialties:
  - 1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Section 22 1319 "Sanitary Waste Piping Specialties."
  - 2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
- P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors.
- R. Install sleeve seals for piping penetrations of concrete walls and slabs.
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

### **3.3 JOINT CONSTRUCTION**

- A. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

- B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

### **3.4 HANGER AND SUPPORT INSTALLATION**

- A. Comply with requirements for pipe hanger and support devices and installation specified below.
  - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
  - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
  - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
  - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
  - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 6. Install individual, straight, horizontal piping runs:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
  - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
  - 2. NPS 3: 48 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
  - 4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.
- F. Install supports for vertical PVC piping every 48 inches.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

### **3.5 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
  - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
  - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
  - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
  - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
  - 5. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

### **3.6 IDENTIFICATION**

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

### **3.7 FIELD QUALITY CONTROL**

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
  - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
  - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

### **3.8 CLEANING AND PROTECTION**

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

### **3.9 PIPING SCHEDULE**

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. (Non Return Air Plenums) aboveground and underground, soil, waste, and vent piping shall be the following:
  1. Solid-wall schedule 40 PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. (Areas With Return Air Plenums) aboveground, soil and waste piping shall be the following:
  1. Hubless cast-iron soil pipe, fittings; heavy-duty hubless-piping couplings, coupled joints.
  2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

**END OF SECTION 22 1316**



**SECTION 22 1319.13**

**SANITARY DRAINS**

**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. Floor drains.

**1.3 DEFINITIONS**

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

**1.4 ACTION SUBMITTALS**

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

**PART 2 - PRODUCTS**

**2.1 DRAIN ASSEMBLIES**

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

## 2.2 FLOOR DRAINS

### A. Cast-Iron Floor Drains FD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Zurn Industries, LLC; model Z415 or a comparable product by one of the following:
  - a. Jay R. Smith Mfg. Co.
  - b. Watts; a Watts Water Technologies company.
2. Standard: ASME A112.6.3.
3. Pattern: Floor drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
9. Backwater Valve: Not required.
10. Coating on Interior and Exposed Exterior Surfaces: Not required.
11. Sediment Bucket: Not required.
12. Top or Strainer Material: Nickel bronze.
13. Top Shape: Round.
14. Dimensions of Top or Strainer: 7".
15. Top Loading Classification: Medium Duty.
16. Funnel: Not required.
17. Inlet Fitting: Not required.
18. Trap Material: Cast iron.
19. Trap Pattern: Deep-seal P-trap.
20. Trap Features: Not required.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- ### A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
  2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
  3. Set with grates depressed according to the following drainage area radii:
    - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
    - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
    - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
  4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.



- a. Maintain integrity of waterproof membranes where penetrated.
- 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

### **3.2 CONNECTIONS**

- A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

### **3.3 PROTECTION**

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

**END OF SECTION 22 1319.13**



**SECTION 22 1413**

**FACILITY STORM DRAINAGE 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. Pipe, tube, and fittings.
  - 2. Specialty pipe fittings.

**1.3 PERFORMANCE REQUIREMENTS**

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
  - 1. Storm Drainage Piping: 10-foot head of water.

**1.4 PROJECT CONDITIONS**

- A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - 1. Notify Owner no fewer than two days in advance of proposed interruption of storm-drainage service.
  - 2. Do not proceed with interruption of storm-drainage service without Owner's written permission.

## **PART 2 - PRODUCTS**

### **2.1 PIPING MATERIALS**

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

### **2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS**

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
  - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. ANACO-Husky.
    - b. Clamp-All Corp.
    - c. Dallas Specialty & Mfg. Co.
    - d. MIFAB, Inc.
    - e. Mission Rubber Company; a division of MCP Industries, Inc.
    - f. Stant.
    - g. Tyler Pipe.
  - 2. Standards: ASTM C 1277 and ASTM C 1540.
  - 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

### **2.3 PVC PIPE AND FITTINGS**

- A. Solid-Wall Schedule 40 PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- C. Adhesive Primer: ASTM F 656.
  - 1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. Solvent Cement: ASTM D 2564.
  - 1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## **2.4 SPECIALTY PIPE FITTINGS**

### **A. Transition Couplings:**

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Shielded, Nonpressure Transition Couplings:
  - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - 1) Cascade Waterworks Mfg. Co.
    - 2) Mission Rubber Company; a division of MCP Industries, Inc.
  - b. Standard: ASTM C 1460.
  - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

## **PART 3 - EXECUTION**

### **3.1 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.

- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
  - 1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
  - 2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.
- K. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
  - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- L. Install aboveground PVC piping according to ASTM D 2665.
- M. Install underground PVC piping according to ASTM D 2321.
- N. Install sleeves for piping penetrations of walls, ceilings, and floors.
- O. Install sleeve seals for piping penetrations of concrete walls and slabs.
- P. Install escutcheons for piping penetrations of walls, ceilings, and floors.

### **3.2 JOINT CONSTRUCTION**

- A. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.
- B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- D. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

### **3.3 SPECIALTY PIPE FITTING INSTALLATION**

- A. Transition Couplings:
  - 1. Install transition couplings at joints of piping with small differences in OD's.
  - 2. In Drainage Piping: Shielded, nonpressure transition couplings.

### **3.4 HANGER AND SUPPORT INSTALLATION**

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
  - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
  - 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
  - 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
  - 4. Individual, Straight, Horizontal Piping Runs:
    - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
  - 5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
  - 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
  - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
  - 2. NPS 3: 60 inches with 1/2-inch rod.
  - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
  - 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
  - 5. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

### **3.5 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

### **3.6 IDENTIFICATION**

- A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

### **3.7 FIELD QUALITY CONTROL**

- A. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
  - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
  - 3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
  - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
  - 5. Prepare reports for tests and required corrective action.

### **3.8 CLEANING AND PROTECTION**

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.



### **3.9 PIPING SCHEDULE**

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. (Non Return Air Plenums) aboveground and underground, soil, waste, and vent piping shall be the following:
  - 1. Solid-wall schedule 40 PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. (Areas With Return Air Plenums) aboveground, soil and waste piping shall be the following:
  - 1. Hubless cast-iron soil pipe, fittings; heavy-duty hubless-piping couplings, coupled joints.
  - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

**END OF SECTION 22 1413**



**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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Liquid-in-glass thermometers.
  - 2. Light-activated thermometers.
  - 3. Thermowells.
  - 4. Dial-type pressure gauges.
  - 5. Gauge attachments.
  - 6. Test plugs.
- B. Related Requirements:
  - 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include diagrams for power, signal, and control wiring.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Product Certificates: For each type of meter and gauge.

**1.5 CLOSEOUT SUBMITTALS**

- A. 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/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ernst Flow Industries.
  - b. Marsh Bellofram.
  - c. Miljoco Corporation.
  - d. Palmer Wahl Instrumentation Group.
  - e. REOTEMP Instrument Corporation.
  - f. WATTS.
  - g. Weiss Instruments, Inc.
2. Standard: ASME B40.200.
3. Case: Plastic or Metal; 7-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: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
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 LIGHT-ACTIVATED THERMOMETERS**

### **A. Direct-Mounted, Light-Activated Thermometers:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Flo Fab Inc.
  - b. REOTEMP Instrument Corporation.
  - c. Terice, H. O. Co.
  - d. Weiss Instruments, Inc.
  - e. Weksler Glass Thermometer Corp.
2. Case: Plastic or Metal; 7-inch nominal size unless otherwise indicated.
3. Scale(s): Deg F and Deg C.
4. Case Form: Adjustable angle.
5. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.
  - a. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus 2 deg F.

## **2.3 THERMOWELLS**

### **A. Thermowells:**

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, 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.**

## **2.4 DIAL-TYPE PRESSURE GAUGES**

### **A. Direct-Mounted, Plastic/Metal-Case, Dial-Type Pressure Gauges:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Ametek U.S. Gauge.
  - b. Flo Fab Inc.
  - c. Tel-Tru Manufacturing Company.
  - d. Terice, H. O. Co.
  - e. WATTS.
  - f. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum, drawn steel or plastic; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
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.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Metal.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

## **2.5 GAUGE ATTACHMENTS**

### **A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.**

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- B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

## **2.6 TEST PLUGS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Flow Design, Inc.
  - 2. Miljoco Corporation.
  - 3. Nexus Valve, Inc.
  - 4. Peterson Equipment Co., Inc.
  - 5. Sisco Manufacturing Company, Inc.
  - 6. Trerice, H. O. Co.
  - 7. WATTS.
- B. Description: Test-station fitting made for insertion in 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, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

## **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. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

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- I. Install permanent indicators on walls or brackets in accessible and readable positions.
- J. Install connection fittings in accessible locations for attachment to portable indicators.
- K. Install thermometers in the following locations:
  - 1. Inlet and outlet of each hydronic zone.
  - 2. Inlet and outlet of each hydronic boiler.
  - 3. Two inlets and two outlets of each chiller.
  - 4. Inlet and outlet of each hydronic coil in air-handling units.
  - 5. Two inlets and two outlets of each hydronic heat exchanger.
- L. Install pressure gauges in the following locations:
  - 1. Discharge of each pressure-reducing valve.
  - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
  - 3. Suction and discharge of each pump.

### **3.2 CONNECTIONS**

- A. Install meters and gauges adjacent to machines and equipment to allow space for 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 SCHEDULE**

- A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
  - 1. Direct-mounted, light-activated type.
  - 2. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers
- B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
  - 1. Direct-mounted, light-activated type.
  - 2. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers
- C. Thermometers at inlets and outlets of each chiller shall be one of the following:
  - 1. Direct-mounted, light-activated type.
  - 2. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
  - 1. Direct-mounted, light-activated type.
  - 2. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers
- E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:

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1. Direct-mounted, light-activated type.
2. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers

F. Thermometer stems shall be of length to match thermowell insertion length.

**3.5 THERMOMETER SCALE-RANGE SCHEDULE**

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- B. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.

**3.6 PRESSURE-GAUGE SCHEDULE**

- A. Pressure gauges at discharge of each pressure-reducing valve shall be one of the following:
  1. Sealed, direct-mounted, metal case.
  2. Sealed, direct-mounted, plastic case.
- B. Pressure gauges at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
  1. Sealed, direct-mounted, metal case.
  2. Sealed, direct-mounted, plastic case.
- C. Pressure gauges at suction and discharge of each pump shall be one of the following:
  1. Sealed, direct-mounted, metal case.
  2. Sealed, direct-mounted, plastic case.

**3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE**

- A. Scale Range for Chilled-Water Piping: 0 to 100 psi.
- B. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

**END OF SECTION 23 0519**



**SECTION 23 0523.12**

**BALL 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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Bronze ball valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.

**1.4 ACTION SUBMITTALS**

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

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces, and weld ends.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
- 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 operating handles or stems as lifting or rigging points.

## **PART 2 - PRODUCTS**

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

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  - 1. ASME B1.20.1 for threads for threaded-end valves.
  - 2. ASME B16.18 for solder-joint connections.
  - 3. ASME B31.9 for building services piping valves.
- C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
  - 1. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
  - 1. Include 2-inch stem extensions.
  - 2. Extended operating handle of non-thermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
  - 3. Memory stops that are fully adjustable after insulation is applied.
- I. Valve Bypass and Drain Connections: MSS SP-45.

### **2.2 BRONZE BALL VALVES**

- A. Bronze Ball Valves, Two-Piece with Regular Port and Stainless-Steel Trim:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Apollo Flow Controls; Conbraco Industries, Inc.
    - b. Hammond Valve.
    - c. Jenkins Valves; Crane Energy Flow Solutions.
    - d. Nibco.

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- 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.
  - h. Stem: Stainless steel.
  - i. Ball: Stainless steel, vented.
  - j. Port: Regular.

### **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 valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

### **3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS**

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
  - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
  - 2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

### **3.4 CHILLED-WATER VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller: bronze ball valves, two piece, with stainless-steel trim, full port, threaded, or solder joint ends.

### **3.5 HEATING-WATER VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller: bronze ball valves, two piece with stainless-steel trim, full port, threaded, or solder joint ends.

**END OF SECTION 23 0523.12**

**SECTION 23 0523.13**

**BUTTERFLY 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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Iron, single-flange butterfly valves.
  - 2. Iron, grooved-end butterfly valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. SWP: Steam working pressure.

**1.4 ACTION SUBMITTALS**

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

**1.5 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 butterfly valves closed or slightly open.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.

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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. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
  1. ASME B16.1 for flanges on iron valves.
  2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
  3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  4. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types:
  1. Handlever: For valves NPS 6 and smaller.
- G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

### **2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES**

- A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. ABZ Valve and Controls.
    - b. Apollo Flow Controls; Conbraco Industries, Inc.
    - c. Hammond Valve.
    - d. NIBCO INC.
    - e. Stockham; Crane Energy Flow Solutions.
  2. Description:
    - a. Standard: MSS SP-67, Type I.

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- 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.

## **2.3 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES**

### **A. Iron, Grooved-End Butterfly Valves, 175 CWP:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Anvil International.
  - b. Grinnell Mechanical Products.
  - c. Kennedy Valve Company; a division of McWane, Inc.
  - d. Mueller Steam Specialty; A WATTS Brand.
  - e. NIBCO INC.
  - f. Shurjoint Piping Products USA Inc.
2. Description:
  - a. Standard: MSS SP-67, Type I.
  - b. CWP Rating: 175 psig.
  - c. Body Material: Coated, ductile iron.
  - d. Stem: Two-piece stainless steel.
  - e. Disc: Coated, ductile iron.
  - f. Seal: EPDM.

## **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 mating flange faces for damage. 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.
- D. 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 valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

### **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 CHILLED-WATER VALVE SCHEDULE**

- A. Pipe NPS 2-1/2 and Larger:
  - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze disc, 200 CWP, and EPDM seat.
  - 2. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.

### **3.5 HEATING-WATER VALVE SCHEDULE**

- A. Pipe NPS 2-1/2 and Larger:
  - 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze disc, 200 CWP, and EPDM seat.
  - 2. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.

**END OF SECTION 23 0523.13**



**SECTION 23 0523.14**

**CHECK 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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Bronze lift check valves.
  - 2. Bronze swing check valves.
  - 3. Iron swing check valves.
  - 4. Iron, grooved-end swing check valves.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. SWP: Steam working pressure.

**1.4 ACTION SUBMITTALS**

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

**1.5 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. Block check valves in either closed or open position.
- B. Use the following precautions during storage:

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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. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
  2. ASME B16.1 for flanges on iron valves.
  3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
  4. ASME B16.18 for solder joint.
  5. ASME B31.1 for power piping valves.
  6. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.

### **2.2 BRONZE LIFT CHECK VALVES**

- A. Bronze Lift Check Valves with Bronze Disc, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Crane; Crane Energy Flow Solutions.
  2. Description:
    - a. Standard: MSS SP-80, Type 1.

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- b. CWP Rating: 200 psig.
- c. Body Design: Vertical flow.
- d. Body Material: ASTM B 61 or ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

B. Bronze Lift Check Valves with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Flo Fab Inc.
  - b. Hammond Valve.
  - c. KITZ Corporation.
  - d. Mueller Steam Specialty; A WATTS Brand.
  - e. NIBCO INC.
2. Description:
  - a. Standard: MSS SP-80, Type 2.
  - b. CWP Rating: 200 psig.
  - c. Body Design: Vertical flow.
  - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
  - e. Ends: Threaded.
  - f. Disc: NBR or PTFE.

## 2.3 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. American Valve, Inc.
  - b. Apollo Flow Controls; Conbraco Industries, Inc.
  - c. Crane; Crane Energy Flow Solutions.
  - d. Jenkins Valves; Crane Energy Flow Solutions.
  - e. KITZ Corporation.
  - f. Macomb Groups (The).
  - g. NIBCO INC.
2. Description:
  - a. Standard: MSS SP-80, Type 3.
  - b. CWP Rating: 300 psig.
  - c. Body Design: Horizontal flow.
  - d. Body Material: ASTM B 62, bronze.
  - e. Ends: Threaded.
  - f. Disc: Bronze.

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B. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Crane; Crane Energy Flow Solutions.
  - b. Hammond Valve.
  - c. Jenkins Valves; Crane Energy Flow Solutions.
  - d. Milwaukee Valve Company.
2. Description:
  - a. Standard: MSS SP-80, Type 4.
  - b. CWP Rating: 300 psig.
  - c. Body Design: Horizontal flow.
  - d. Body Material: ASTM B 62, bronze.
  - e. Ends: Threaded.
  - f. Disc: PTFE.

## 2.4 IRON SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Apollo Flow Controls; Conbraco Industries, Inc.
  - b. Crane; Crane Energy Flow Solutions.
  - c. Hammond Valve.
  - d. Jenkins Valves; Crane Energy Flow Solutions.
  - e. KITZ Corporation.
  - f. NIBCO INC.
2. Description:
  - a. Standard: MSS SP-71, Type I.
  - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
  - c. NPS 14 to NPS 24, 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.

## 2.5 IRON, GROOVED-END SWING CHECK VALVES

A. Iron, Grooved-End Swing Check Valves, 300 CWP:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Anvil International.
  - b. Grinnell Mechanical Products.
  - c. Shurjoint Piping Products USA Inc.
2. Description:
  - a. CWP Rating: 300 psig.
  - b. Body Material: ASTM A 536, ductile iron.
  - c. Seal: EPDM.
  - d. Disc: Spring operated, ductile iron or stainless steel.

### **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.

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2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
  3. Lift Check Valves: With stem upright and plumb.
- F. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

### **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. Pump-Discharge Check Valves:
    - a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
    - b. NPS 2-1/2 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 unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
  2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
  3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
  4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
  5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
  6. For Steel Piping, NPS 5 and Larger: Flanged ends.

### **3.5 CHILLED-WATER VALVE SCHEDULE**

- A. Pipe NPS 2 and Smaller:
1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
  2. Bronze swing check valves with bronze disc, Class 150.
- B. Pipe NPS 2-1/2 and Larger:
1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.

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2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring closure control, Class 125.
3. NPS 3 to NPS 12: Iron, grooved-end swing check valves, 300 CWP.

**3.6 HEATING-WATER VALVE SCHEDULE**

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze swing check valves with bronze disc, Class 150.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring-closure control, Class 125.
3. NPS 3 to NPS 12: Iron, grooved-end swing check valves, 300 CWP.

**END OF SECTION 23 0523.14**





**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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal pipe hangers and supports.
  - 2. Trapeze pipe hangers.
  - 3. Fiberglass pipe hangers.
  - 4. Metal framing systems.
  - 5. Thermal-hanger shield inserts.
  - 6. Fastener systems.
  - 7. Pipe stands.
  - 8. Equipment supports.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
  - 1. Trapeze pipe hangers.
  - 2. Metal framing systems.
  - 3. Fiberglass strut systems.
  - 4. Pipe stands.
  - 5. Equipment supports.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Welding certificates.

## **1.5 QUALITY ASSURANCE**

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

## **PART 2 - PRODUCTS**

### **2.1 METAL PIPE HANGERS AND SUPPORTS**

- A. Carbon-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
  - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
  - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
  - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
  - 1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
  - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

### **2.2 TRAPEZE PIPE HANGERS**

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

### **2.3 FIBERGLASS PIPE HANGERS**

- A. Clevis-Type, Fiberglass Pipe Hangers:

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1. Description: Similar to MSS SP-58, Type 1, factory-fabricated steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass polyurethane or stainless steel.
3. Flammability: ASTM D 635, ASTM E 84, and UL 94.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
  - a. Flammability: ASTM D 635, ASTM E 84, and UL 94.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

## 2.4 PLASTIC PIPE HANGERS

- A. Description: Similar to MSS SP-58, Types 1 through 58, factory-fabricated steel pipe hanger except hanger is made of plastic.
- B. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
- C. Flammability: ASTM D 635, ASTM E 84, and UL 94.

## 2.5 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. B-line, an Eaton business.
  - b. Flex-Strut Inc.
  - c. G-Strut.
  - d. Haydon Corporation.
  - e. MIRO Industries.
  - f. Thomas & Betts Corporation; A Member of the ABB Group.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
8. Paint Coating: Green epoxy, acrylic, or urethane.

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B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Anvil International.
  - b. Carpenter & Paterson, Inc.
  - c. Empire Industries, Inc.
  - d. ERICO International Corporation.
  - e. Gripple Inc.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Select for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
8. Paint Coating: Green epoxy, acrylic, or urethane.

## 2.6 FIBERGLASS STRUT SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Champion Fiberglass, Inc.
  2. Fabco Plastics Wholesale Limited.
  3. G-Strut.
- B. Description: Structural-grade, factory-formed, glass-fiber-resin channels and angles for supporting multiple parallel pipes.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
  2. Channels: Continuous slotted fiberglass-reinforced plastic channel with inturned lips.
  3. Channel Width: Selected for applicable load criteria.
  4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
  5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
  6. Rated Strength: Selected to suit applicable load criteria.
  7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

## 2.7 THERMAL-HANGER SHIELD INSERTS

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

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1. [Buckaroos, Inc.](#)
  2. [Carpenter & Paterson, Inc.](#)
  3. [Clement Support Services.](#)
  4. [ERICO International Corporation.](#)
  5. [National Pipe Hanger Corporation.](#)
  6. [Pipe Shields Inc.](#)
  7. [Piping Technology & Products, Inc.](#)
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psi or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
- 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.

## 2.8 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; Illinois Tool Works, Inc.](#)
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors 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, an Eaton business.](#)
    - b. [Empire Tool and Manufacturing Co., Inc.](#)
    - c. [Hilti, Inc.](#)
  2. Indoor Applications: Zinc-coated or stainless-steel.
  3. Outdoor Applications: Stainless steel.

## **2.9 PIPE STANDS**

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand:
  - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
  - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
  - 3. Hardware: Galvanized steel or polycarbonate.
  - 4. Accessories: Protection pads.
- C. Low-Profile, Single Base, Single-Pipe Stand:
  - 1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
  - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
  - 3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch rods.
  - 4. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels.
  - 5. Pipe Supports: Strut clamps.
  - 6. Hardware: Galvanized steel.
  - 7. Accessories: Protection pads.
  - 8. Height: 12 inches above roof.

## **2.10 EQUIPMENT SUPPORTS**

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

## **2.11 MATERIALS**

- A. Aluminum: ASTM B 221.
- B. Carbon Steel: ASTM A 1011/A 1011M.
- C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A 240/A 240M.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

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

### **PART 3 - EXECUTION**

#### **3.1 APPLICATION**

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

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

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. 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 for individual pipe hangers.
  - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. 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.

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2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
  2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.



3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
  - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
  - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
  - b. NPS 4: 12 inches long and 0.06 inch thick.
  - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
  - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
  - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. 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 bearing surface smooth.
- 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/D1.1M 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 so contours of welded surfaces match adjacent contours.

### **3.5 ADJUSTING**

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

### **3.6 PAINTING**

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

### **3.7 HANGER AND SUPPORT SCHEDULE**

- A. Specific hanger and support requirements are 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 carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.

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- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
  - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, 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 36, requiring clamp flexibility and up to 4 inches of insulation.
  - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
  - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
  - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
  - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
  - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
  - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
  - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
  - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
  - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
  - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
  - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
  - 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
  - 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
  - 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two 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 24, from single rod if horizontal movement caused by expansion and contraction might occur.
  - 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
  - 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.

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21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. 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 24.
  2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
  3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
  4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
  2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
  3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  6. C-Clamps (MSS Type 23): For structural shapes.
  7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
  9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    - a. Light (MSS Type 31): 750 lb.
    - b. Medium (MSS Type 32): 1500 lb.
    - c. Heavy (MSS Type 33): 3000 lb.

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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.
- N. 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.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
  2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
  3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
  4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
  5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
  6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
  7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
  8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    - a. Horizontal (MSS Type 54): Mounted horizontally.
    - b. Vertical (MSS Type 55): Mounted vertically.
    - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

**END OF SECTION 23 0529**



**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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Pipe labels.
  - 3. Duct labels.
  - 4. Valve tags.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

**PART 2 - PRODUCTS**

**2.1 EQUIPMENT LABELS**

- A. Plastic Labels for Equipment:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Brady Corporation.

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- b. Brimar Industries, Inc.
  - c. Carlton Industries, LP.
  - d. Champion America.
  - e. Craftmark Pipe Markers.
  - f. Kolbi Pipe Marker Co.
- 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- 3. Letter Color: White.
- 4. Background Color: Black.
- 5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- 6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- 7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

## 2.2 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Brady Corporation.
  - 2. Brimar Industries, Inc.
  - 3. Carlton Industries, LP.
  - 4. Champion America.
  - 5. Craftmark Pipe Markers.
  - 6. Kolbi Pipe Marker Co.
  - 7. LEM Products Inc.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.



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1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

## **2.3 DUCT LABELS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Brady Corporation.
  2. Brimar Industries, Inc.
  3. Carlton Industries, LP.
  4. Champion America.
  5. Craftmark Pipe Markers.
  6. Kolbi Pipe Marker Co.
  7. LEM Products Inc.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Blue, Yellow and Green.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
  1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

## **2.4 VALVE TAGS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Brady Corporation.
  - 2. Brimar Industries, Inc.
  - 3. Carlton Industries, LP.
  - 4. Champion America.
  - 5. Craftmark Pipe Markers.
  - 6. Kolbi Pipe Marker Co.
  - 7. LEM Products Inc.
- B. Description: 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 chain or beaded chain or S-hook.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
  - 1. Valve-tag schedule shall be included in operation and maintenance data.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

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

### **3.2 GENERAL INSTALLATION REQUIREMENTS**

- 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.

### **3.3 EQUIPMENT LABEL INSTALLATION**

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

### **3.4 PIPE LABEL INSTALLATION**

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Pipe Label Locations: 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 and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
  - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- D. Pipe Label Color Schedule:
  - 1. Chilled-Water Piping: White letters on a safety-green background.
  - 2. Heating Water Piping: White letters on a safety-green background.
  - 3. Low Pressure Steam Piping: White letters on a safety-green background.
  - 4. Condensate Return Piping: White letters on a safety-green background.

### **3.5 DUCT LABEL INSTALLATION**

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
  - 1. Blue: For cold-air supply ducts.
  - 2. Yellow: For hot-air supply ducts.
  - 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

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- B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

**3.6 VALVE-TAG INSTALLATION**

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
  - 1. Valve-Tag Size and Shape:
    - a. Chilled Water: 1-1/2 inches, round.
    - b. Hot Water: 1-1/2 inches, round.
    - c. Low Pressure Steam: 1-1/2 inches, round.
  - 2. Valve-Tag Colors:
    - a. Potable and Other Water: White letters on a safety-green background.

**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.

**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.
    - c. Primary-secondary hydronic systems.
  - 3. Balancing steam systems.
  - 4. Testing, Adjusting, and Balancing Equipment:
    - a. Heat exchangers.
    - b. Motors.
    - c. Chillers.
    - d. Condensing units.
    - e. Boilers.
    - f. Heat-transfer coils.
  - 5. Testing, adjusting, and balancing existing systems and equipment.
  - 6. Control system verification.

**1.3 DEFINITIONS**

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.

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- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- B. Certified TAB reports.
- C. Sample report forms.
- D. 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 Specialists Qualifications: Certified by AABC.
  - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
  - 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.
- B. TAB Specialists Qualifications: Certified by NEBB or TABB.
  - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
  - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

**1.6 FIELD 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.

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- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

**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.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
  - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

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- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

### **3.2 PREPARATION**

- A. Prepare a TAB plan that includes the following:
  - 1. Equipment and systems to be tested.
  - 2. Strategies and step-by-step procedures for balancing the systems.
  - 3. Instrumentation to be used.
  - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
  - 1. Airside:
    - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    - b. Duct systems are complete with terminals installed.
    - c. Volume, smoke, and fire dampers are open and functional.
    - d. Clean filters are installed.
    - e. Fans are operating, free of vibration, and rotating in correct direction.
    - f. Variable-frequency controllers' startup is complete and safeties are verified.
    - g. Automatic temperature-control systems are operational.
    - h. Ceilings are installed.
    - i. Windows and doors are installed.
    - j. Suitable access to balancing devices and equipment is provided.
  - 2. Hydronics:
    - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
    - b. Piping is complete with terminals installed.



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- c. Water treatment is complete.
- d. Systems are flushed, filled, and air purged.
- e. Strainers are pulled and cleaned.
- f. Control valves are functioning per the sequence of operation.
- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete and safeties are verified.
- k. Suitable access to balancing devices and equipment is provided.

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

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and 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. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
  - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "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. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

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- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "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.
    - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
  - 2. Measure fan static pressures as follows:
    - a. Measure static pressure directly at the fan outlet or through the flexible connection.
    - b. Measure static pressure directly at the fan inlet or through the flexible connection.
    - c. Measure static pressure across each component that makes up the air-handling system.
    - d. Report artificial loading of filters at the time static pressures are measured.
  - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
  - 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

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- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
  - 1. Measure airflow of submain and branch ducts.
  - 2. Adjust submain and branch duct volume dampers for specified airflow.
  - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
  - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
  - 2. Measure inlets and outlets airflow.
  - 3. Adjust each inlet and outlet for specified airflow.
  - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
  - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
  - 2. Re-measure and confirm that total airflow is within design.
  - 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
  - 4. Mark all final settings.
  - 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
  - 6. Measure and record all operating data.
  - 7. Record final fan-performance data.

### **3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS**

- A. Adjust the variable-air-volume systems as follows:
  - 1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
  - 2. Verify that the system is under static pressure control.
  - 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
  - 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    - d. Adjust controls so that terminal is calling for minimum airflow.

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- e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
  - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
  - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
- a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
  - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
  - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
  - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
  - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
- a. Measure static pressure directly at the fan outlet or through the flexible connection.
  - b. Measure static pressure directly at the fan inlet or through the flexible connection.
  - c. Measure static pressure across each component that makes up the air-handling system.
  - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
- a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
  - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
- a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
  - b. Re-measure and confirm that total airflow is within design.
  - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
  - d. Mark final settings.

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- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans.

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

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
  - 1. Check liquid level in expansion tank.
  - 2. Check highest vent for adequate pressure.
  - 3. Check flow-control valves for proper position.
  - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
  - 5. Verify that motor starters are equipped with properly sized thermal protection.
  - 6. Check that air has been purged from the system.

### **3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS**

- A. Adjust pumps to deliver total design gpm.
  - 1. Measure total water flow.
    - a. Position valves for full flow through coils.
    - b. Measure flow by main flow meter, if installed.
    - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
  - 2. Measure pump TDH as follows:
    - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    - c. Convert pressure to head and correct for differences in gage heights.
    - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
    - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  - 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.

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1. Measure flow in main and branch pipes.
  2. Adjust main and branch balance valves for design flow.
  3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
  2. Adjust each terminal to design flow.
  3. Re-measure each terminal after it is adjusted.
  4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
  5. Perform temperature tests after flows have been balanced.
- D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
  2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
  2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
  2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  3. Mark final settings.
- G. Verify that memory stops have been set.

### **3.9 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.
- B. Adjust the variable-flow hydronic system as follows:
1. Verify that the differential-pressure sensor is located as indicated.
  2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
1. Adjust pumps to deliver total design gpm.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.

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- 2) Measure flow by main flow meter, if installed.
    - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
  - b. Measure pump TDH as follows:
    - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    - 3) Convert pressure to head and correct for differences in gage heights.
    - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
  - a. Measure flow in main and branch pipes.
  - b. Adjust main and branch balance valves for design flow.
  - c. Re-measure each main and branch after all have been adjusted.
3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
  - a. Measure flow at terminals.
  - b. Adjust each terminal to design flow.
  - c. Re-measure each terminal after it is adjusted.
  - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
  - e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
  - a. Measure differential pressure and verify that it is within manufacturer's specified range.
  - b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
  - a. Measure and balance coils by either coil pressure drop or temperature method.
  - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system differential-pressure set point.

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7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
  8. Mark final settings and verify that all memory stops have been set.
  9. Verify final system conditions as follows:
    - a. Re-measure and confirm that total water flow is within design.
    - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    - c. Mark final settings.
  10. Verify that memory stops have been set.
- D. For systems with diversity:
1. Determine diversity factor.
  2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
  3. Adjust pumps to deliver total design gpm.
    - a. Measure total water flow.
      - 1) Position valves for full flow through coils.
      - 2) Measure flow by main flow meter, if installed.
      - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
    - b. Measure pump TDH as follows:
      - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      - 3) Convert pressure to head and correct for differences in gage heights.
      - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
      - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
    - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
  4. Adjust flow-measuring devices installed in mains and branches to design water flows.
    - a. Measure flow in main and branch pipes.
    - b. Adjust main and branch balance valves for design flow.
    - c. Re-measure each main and branch after all have been adjusted.
  5. Adjust flow-measuring devices installed at terminals for each space to design water flows.



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- a. Measure flow at terminals.
  - b. Adjust each terminal to design flow.
  - c. Re-measure each terminal after it is adjusted.
  - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
  - e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
  - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
  - b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
  - a. Measure and balance coils by either coil pressure drop or temperature method.
  - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
  - a. Re-measure and confirm that total water flow is within design.
  - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  - c. Mark final settings.
13. Verify that memory stops have been set.

**3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS**

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.
- C. Adjust pumps to deliver total design gpm.
  1. Measure total water flow.
    - a. Position valves for full flow through coils.
    - b. Measure flow by main flow meter, if installed.
    - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

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2. Measure pump TDH as follows:
    - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    - c. Convert pressure to head and correct for differences in gage heights.
    - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
  3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
  2. Adjust main and branch balance valves for design flow.
  3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
  2. Adjust each terminal to design flow.
  3. Re-measure each terminal after it is adjusted.
  4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
  5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
  2. Perform temperature tests after flows have been verified.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
  2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
  2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
  3. Mark final settings.
- I. Verify that memory stops have been set.

### **3.11 PROCEDURES FOR HEAT EXCHANGERS**

- A. Adjust water flow to within specified tolerances.
- B. Measure inlet and outlet water temperatures.
- C. Measure inlet steam pressure.
- D. Check settings and operation of safety and relief valves. Record settings.

### **3.12 PROCEDURES FOR MOTORS**

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
  - 1. Manufacturer's name, model number, and serial number.
  - 2. Motor horsepower rating.
  - 3. Motor rpm.
  - 4. Phase and hertz.
  - 5. Nameplate and measured voltage, each phase.
  - 6. Nameplate and measured amperage, each phase.
  - 7. Starter size and thermal-protection-element rating.
  - 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

### **3.13 PROCEDURES FOR CHILLERS**

- A. Balance water flow through each evaporator to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
  - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
  - 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
  - 3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
  - 4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
  - 5. Capacity: Calculate in tons of cooling.
  - 6. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

### **3.14 PROCEDURES FOR CONDENSING UNITS**

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

### **3.15 PROCEDURES FOR BOILERS**

- A. Hydronic Boilers:
  - 1. Measure and record entering- and leaving-water temperatures.
  - 2. Measure and record water flow.
  - 3. Record relief valve pressure setting.

### **3.16 PROCEDURES FOR HEAT-TRANSFER COILS**

- A. Measure, adjust, and record the following data for each water coil:
  - 1. Entering- and leaving-water temperature.
  - 2. Water flow rate.
  - 3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
  - 4. Dry-bulb temperature of entering and leaving air.
  - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
  - 6. Airflow.
- B. Measure, adjust, and record the following data for each electric heating coil:
  - 1. Nameplate data.
  - 2. Airflow.
  - 3. Entering- and leaving-air temperature at full load.
  - 4. Voltage and amperage input of each phase at full load.
  - 5. Calculated kilowatt at full load.
  - 6. Fuse or circuit-breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each steam coil:
  - 1. Dry-bulb temperature of entering and leaving air.
  - 2. Airflow.
  - 3. Inlet steam pressure.
- D. Measure, adjust, and record the following data for each refrigerant coil:
  - 1. Dry-bulb temperature of entering and leaving air.
  - 2. Wet-bulb temperature of entering and leaving air.
  - 3. Airflow.

### **3.17 TOLERANCES**

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
  - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
  - 2. Air Outlets and Inlets: Plus or minus 10 percent.
  - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
  - 4. Cooling-Water Flow Rate: Plus or minus 10 percent.

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- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

**3.18 FINAL REPORT**

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
  - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
  - 2. Include a list of instruments used for procedures, along with proof of calibration.
  - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
  - 1. Pump curves.
  - 2. Fan curves.
  - 3. Manufacturers' test data.
  - 4. Field test reports prepared by system and equipment installers.
  - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
  - 1. Title page.
  - 2. Name and address of the TAB specialist.
  - 3. Project name.
  - 4. Project location.
  - 5. Architect's name and address.
  - 6. Engineer's name and address.
  - 7. Contractor's name and address.
  - 8. Report date.
  - 9. Signature of TAB supervisor who certifies the report.
  - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  - 11. Summary of contents including the following:
    - a. Indicated versus final performance.
    - b. Notable characteristics of systems.
    - c. Description of system operation sequence if it varies from the Contract Documents.
  - 12. Nomenclature sheets for each item of equipment.
  - 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
  - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
  - 15. Test conditions for fans 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.

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- d. Face and bypass damper settings at coils.
  - e. Fan drive settings including settings and percentage of maximum pitch diameter.
  - f. Inlet vane settings for variable-air-volume systems.
  - g. Settings for supply-air, static-pressure controller.
  - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
  - 1. Quantities of outdoor, supply, return, and exhaust airflows.
  - 2. Water and steam flow rates.
  - 3. Duct, outlet, and inlet sizes.
  - 4. Pipe and valve sizes and locations.
  - 5. Terminal units.
  - 6. Balancing stations.
  - 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units 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.
    - h. Sheave make, size in inches, and bore.
    - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    - j. Number, make, and size of belts.
    - k. Number, type, and size of filters.
  - 2. Motor Data:
    - a. Motor make, and frame type and size.
    - b. Horsepower and rpm.
    - c. Volts, phase, and hertz.
    - d. Full-load amperage and service factor.
    - e. Sheave make, size in inches, and bore.
    - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
  - 3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.
    - b. Total system static pressure in inches wg.
    - c. Fan rpm.
    - d. Discharge static pressure in inches wg.
    - e. Filter static-pressure differential in inches wg.
    - f. Preheat-coil static-pressure differential in inches wg.
    - g. Cooling-coil static-pressure differential in inches wg.

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- h. Heating-coil static-pressure differential in inches wg.
  - i. Outdoor airflow in cfm.
  - j. Return airflow in cfm.
  - k. Outdoor-air damper position.
  - l. Return-air damper position.
  - m. Vortex damper position.
- F. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
  - 1. Unit Data:
    - a. System identification.
    - b. Location.
    - c. Make and type.
    - d. Model number and unit size.
    - e. Manufacturer's serial number.
    - f. Fuel type in input data.
    - g. Output capacity in Btu/h.
    - h. Ignition type.
    - i. Burner-control types.
    - j. Motor horsepower and rpm.
    - k. Motor volts, phase, and hertz.
    - l. Motor full-load amperage and service factor.
    - m. Sheave make, size in inches, and bore.
    - n. Center-to-center dimensions of sheave and amount of adjustments in inches.
  - 2. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.
    - b. Entering-air temperature in deg F.
    - c. Leaving-air temperature in deg F.
    - d. Air temperature differential in deg F.
    - e. Entering-air static pressure in inches wg.
    - f. Leaving-air static pressure in inches wg.
    - g. Air static-pressure differential in inches wg.
    - h. Low-fire fuel input in Btu/h.
    - i. High-fire fuel input in Btu/h.
    - j. Manifold pressure in psig.
    - k. High-temperature-limit setting in deg F.
    - l. Operating set point in Btu/h.
    - m. Motor voltage at each connection.
    - n. Motor amperage for each phase.
    - o. Heating value of fuel in Btu/h.
- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
  - 1. Fan Data:
    - a. System identification.
    - b. Location.

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- c. Make and type.
  - d. Model number and size.
  - e. Manufacturer's serial number.
  - f. Arrangement and class.
  - g. Sheave make, size in inches, and bore.
  - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
- 2. Motor Data:
  - a. Motor make, and frame type and size.
  - b. Horsepower and rpm.
  - c. Volts, phase, and hertz.
  - d. Full-load amperage and service factor.
  - e. Sheave make, size in inches, and bore.
  - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
  - g. Number, make, and size of belts.
- 3. Test Data (Indicated and Actual Values):
  - a. Total airflow rate in cfm.
  - b. Total system static pressure in inches wg.
  - c. Fan rpm.
  - d. Discharge static pressure in inches wg.
  - e. Suction static pressure in inches wg.
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  - 1. Report Data:
    - a. System and air-handling-unit number.
    - b. Location and zone.
    - c. Traverse air temperature in deg F.
    - d. Duct static pressure in inches wg.
    - e. Duct size in inches.
    - f. Duct area in sq. ft..
    - g. Indicated airflow rate in cfm.
    - h. Indicated velocity in fpm.
    - i. Actual airflow rate in cfm.
    - j. Actual average velocity in fpm.
    - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
  - 1. Unit Data:
    - a. System and air-handling unit identification.
    - b. Location and zone.
    - c. Apparatus used for test.
    - d. Area served.
    - e. Make.



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- f. Number from system diagram.
    - g. Type and model number.
    - h. Size.
    - i. Effective area in sq. ft..
  - 2. Test Data (Indicated and Actual Values):
    - a. Airflow rate in cfm.
    - b. Air velocity in fpm.
    - c. Preliminary airflow rate as needed in cfm.
    - d. Preliminary velocity as needed in fpm.
    - e. Final airflow rate in cfm.
    - f. Final velocity in fpm.
    - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
- 1. Unit Data:
    - a. System and air-handling-unit identification.
    - b. Location and zone.
    - c. Room or riser served.
    - d. Coil make and size.
    - e. Flowmeter type.
  - 2. Test Data (Indicated and Actual Values):
    - a. Airflow rate in cfm.
    - b. Entering-water temperature in deg F.
    - c. Leaving-water temperature in deg F.
    - d. Water pressure drop in feet of head or psig.
    - e. Entering-air temperature in deg F.
    - f. Leaving-air temperature in deg F.
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
- 1. Unit Data:
    - a. Unit identification.
    - b. Location.
    - c. Service.
    - d. Make and size.
    - e. Model number and serial number.
    - f. Water flow rate in gpm.
    - g. Water pressure differential in feet of head or psig.
    - h. Required net positive suction head in feet of head or psig.
    - i. Pump rpm.
    - j. Impeller diameter in inches.
    - k. Motor make and frame size.
    - l. Motor horsepower and rpm.

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- m. Voltage at each connection.
  - n. Amperage for each phase.
  - o. Full-load amperage and service factor.
  - p. Seal type.
- 2. Test Data (Indicated and Actual Values):
  - a. Static head in feet of head or psig.
  - b. Pump shutoff pressure in feet of head or psig.
  - c. Actual impeller size in inches.
  - d. Full-open flow rate in gpm.
  - e. Full-open pressure in feet of head or psig.
  - f. Final discharge pressure in feet of head or psig.
  - g. Final suction pressure in feet of head or psig.
  - h. Final total pressure in feet of head or psig.
  - i. Final water flow rate in gpm.
  - j. Voltage at each connection.
  - k. Amperage for each phase.
- L. Instrument Calibration Reports:
  - 1. Report Data:
    - a. Instrument type and make.
    - b. Serial number.
    - c. Application.
    - d. Dates of use.
    - e. Dates of calibration.

**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.

**1.2 SUMMARY**

- A. Section includes insulating the following duct services:
  - 1. Indoor, concealed supply and outdoor air.
  - 2. Indoor, exposed supply and outdoor air.
  - 3. Indoor, concealed return located in unconditioned space.
  - 4. Indoor, exposed return located in unconditioned space.
  - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
  - 7. Indoor, concealed mixed-air ductwork
  - 8. Indoor, exposed mixed-air ductwork
- B. Related Sections:
  - 1. Section 230716 "HVAC Equipment Insulation."
  - 2. Section 230719 "HVAC Piping Insulation."

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
  - 3. Detail application of field-applied jackets.
  - 4. Detail application at linkages of control devices.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

#### **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

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

#### **1.7 COORDINATION**

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with 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.

## 1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

## PART 2 - PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. CertainTeed Corporation.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. Knauf Insulation.

### 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.

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- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

## **2.3 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
  - 2. Service Temperature Range: 0 to 180 deg F.
  - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
  - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
  - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
  - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
  - 4. Color: White.

## **2.4 SEALANTS**

- A. FSK and Metal Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 4. Color: White.

## **2.5 FACTORY-APPLIED JACKETS**

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

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1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

## 2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Johns Manville; a Berkshire Hathaway company.
    - b. P.I.C. Plastics, Inc.
  2. Adhesive: As recommended by jacket material manufacturer.
  3. Color: White.
- D. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with stucco-embossed aluminum-foil facing.

## 2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  1. Width: 3 inches.
  2. Thickness: 11.5 mils.
  3. Adhesion: 90 ounces force/inch in width.
  4. Elongation: 2 percent.
  5. Tensile Strength: 40 lbf/inch in width.
  6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  1. Width: 3 inches.
  2. Thickness: 6.5 mils.
  3. Adhesion: 90 ounces force/inch in width.
  4. Elongation: 2 percent.

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5. Tensile Strength: 40 lbf/inch in width.
  6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
  2. Thickness: 6 mils.
  3. Adhesion: 64 ounces force/inch in width.
  4. Elongation: 500 percent.
  5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
  2. Thickness: 3.7 mils.
  3. Adhesion: 100 ounces force/inch in width.
  4. Elongation: 5 percent.
  5. Tensile Strength: 34 lbf/inch in width.

## **2.8 CORNER ANGLES**

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 PREPARATION**

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



### 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, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. 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, 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.
- 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. 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.

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4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to 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.

### **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: 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 Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

### 3.5 INSTALLATION OF MINERAL-FIBER INSULATION

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 overcompress insulation during installation.
  - e. Impale insulation over pins and attach speed washers.
  - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

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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 overcompress insulation during installation.
    - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
  5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

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6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

### **3.6 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 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.
- C. 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 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
  1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.8 DUCT INSULATION SCHEDULE, GENERAL**

- A. Plenums and Ducts Requiring Insulation:
  1. Indoor, concealed supply and outdoor air.
  2. Indoor, exposed supply and outdoor air.
  3. Indoor, concealed return located in unconditioned space.
  4. Indoor, exposed return located in unconditioned space.

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5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.
9. Indoor, concealed mixed-air ductwork
10. Indoor, exposed mixed-air ductwork

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

### 3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round, supply-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- B. Concealed, round, outdoor-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- C. Concealed, rectangular, supply-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- D. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- E. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- F. Concealed, supply-air plenum insulation shall be one of the following:
  1. Mineral-Fiber Board: 2 inches thick providing minimum insulation factor of R-6 after installation and 3.0-lb/cu. ft. nominal density.
- G. Concealed, outdoor-air plenum insulation shall be one of the following:
  1. Mineral-Fiber Board: 2 inches thick providing minimum insulation factor of R-6 after installation and 3.0-lb/cu. ft. nominal density.
- H. Concealed, exhaust-air plenum insulation shall be one of the following:

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1. Mineral-Fiber Board: 2 inches thick providing minimum insulation factor of R-6 after installation and 3.0-lb/cu. ft. nominal density.
- I. Exposed, round, outdoor-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- J. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- K. Exposed, outdoor-air plenum insulation shall be one of the following:
  1. Mineral-Fiber Board: 2 inches thick providing minimum insulation factor of R-6 after installation and 3.0-lb/cu. ft. nominal density.
- L. All un-insulated surfaces of hot water reheat coils shall be insulated with one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 3.0-lb/cu. ft. nominal density.
- M. Concealed, rectangular, mixed-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.
- N. Exposed, rectangular, mixed-air duct insulation shall be one of the following:
  1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.

**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.

**1.2 SUMMARY**

- A. Section includes insulating the following HVAC equipment that is not factory insulated:
  - 1. Chilled-water pumps.
  - 2. Chilled-water air separator.
  - 3. Chilled-water side-stream filters.
  - 4. Chilled-water remote evaporator.
- B. Related Sections:
  - 1. Section 230713 "Duct Insulation."
  - 2. Section 230719 "HVAC Piping Insulation."

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Sustainable Design Submittals:
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail removable insulation at equipment connections.
  - 4. Detail application of field-applied jackets.
  - 5. Detail application at linkages of control devices.
  - 6. Detail field application for each equipment type.

#### **1.4 QUALITY ASSURANCE**

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

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

#### **1.6 COORDINATION**

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

#### **1.7 SCHEDULING**

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

### **PART 2 - PRODUCTS**

#### **2.1 INSULATION MATERIALS**

- A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

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- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. Aeroflex USA, Inc.
    - b. Armacell LLC.

## **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 and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Aeroflex USA, Inc.
    - b. Armacell LLC.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
  - 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.3 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 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, anchors, and other projections with vapor-barrier mastic.

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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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- 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.
  6. Cleanouts.

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

- A. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
  2. Seal longitudinal seams and end joints.

### **3.5 FINISHES**

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

### **3.6 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.7 EQUIPMENT INSULATION SCHEDULE**

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.
- C. Chilled-water pump insulation shall be one of the following:
  - 1. Flexible Elastomeric: 1 inch thick.
- D. Chilled-water air-separator insulation shall be one of the following:
  - 1. Flexible Elastomeric: 1 inch thick.
- E. Side-Stream filter-housing insulation shall be one of the following:
  - 1. Flexible Elastomeric: 1 inch thick.
- F. Chilled-water remote evaporator insulation shall be one of the following:
  - 1. Flexible Elastomeric: 1 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.

**1.2 SUMMARY**

- A. Section includes insulating the following HVAC piping systems:
  - 1. Condensate drain piping, indoors.
  - 2. Chilled-water piping, indoors and outdoors.
  - 3. Heating hot-water piping, indoors.
  - 4. Refrigerant suction and hot-gas piping, indoors and outdoors.
  - 5. Steam and steam condensate piping, indoors.
- B. Related Sections:
  - 1. Section 230713 "Duct Insulation."
  - 2. Section 230716 "HVAC Equipment Insulation."

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail insulation application at pipe expansion joints for each type of insulation.
  - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Detail removable insulation at piping specialties.
  - 6. Detail application of field-applied jackets.
  - 7. Detail application at linkages of control devices.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

#### **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

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

#### **1.7 COORDINATION**

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.



## 1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

## PART 2 - PRODUCTS

### 2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Aeroflex USA, Inc.
    - b. Airex Manufacturing.
- G. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. CertainTeed Corporation.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. Knauf Insulation.

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H. Mineral-Fiber, Preformed Pipe Insulation:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Johns Manville; a Berkshire Hathaway company.
  - b. Knauf Insulation.
  - c. CertainTeed Corporation.
2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. CertainTeed Corporation.
  - b. Johns Manville; a Berkshire Hathaway company.
  - c. Knauf Insulation.

## 2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

## 2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

## **2.4 MASTICS**

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
  - 2. Service Temperature Range: 0 to 180 deg F.
  - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
  - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
  - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
  - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
  - 4. Color: White.

## **2.5 SEALANTS**

- A. FSK and Metal Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
  - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
  - 2. Fire- and water-resistant, flexible, elastomeric sealant.
  - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
  - 4. Color: White.

## **2.6 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.

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3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
  - a. <Double click here to find, evaluate, and insert list of manufacturers and products.>
6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

## 2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Airex Manufacturing.
    - b. Johns Manville; a Berkshire Hathaway company.
    - c. P.I.C. Plastics, Inc.
  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.
- D. Metal Jacket:

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1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
  - a. 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 Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
  - d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
  - e. Factory-Fabricated Fitting Covers:
    - 1) Same material, finish, and thickness as jacket.
    - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    - 3) Tee covers.
    - 4) Flange and union covers.
    - 5) End caps.
    - 6) Beveled collars.
    - 7) Valve covers.
    - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.

## 2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  1. Width: 3 inches.
  2. Thickness: 11.5 mils.
  3. Adhesion: 90 ounces force/inch in width.
  4. Elongation: 2 percent.
  5. Tensile Strength: 40 lbf/inch in width.
  6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  1. Width: 3 inches.
  2. Thickness: 6.5 mils.
  3. Adhesion: 90 ounces force/inch in width.
  4. Elongation: 2 percent.
  5. Tensile Strength: 40 lbf/inch in width.
  6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
  1. Width: 2 inches.

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2. Thickness: 6 mils.
  3. Adhesion: 64 ounces force/inch in width.
  4. Elongation: 500 percent.
  5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
  2. Thickness: 3.7 mils.
  3. Adhesion: 100 ounces force/inch in width.
  4. Elongation: 5 percent.
  5. Tensile Strength: 34 lbf/inch in width.

## **2.9 SECUREMENTS**

- A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
  2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
  3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
  2. Verify that surfaces to be insulated are clean and dry.
  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. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F.

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- Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.3 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 item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
  2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
  4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    - a. For below-ambient services, apply vapor-barrier mastic over staples.
  - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.
  - 4. Manholes.
  - 5. Handholes.
  - 6. Cleanouts.

### 3.4 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.



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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.
1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
  2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

### **3.5 GENERAL PIPE INSULATION INSTALLATION**

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, 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.

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4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
  5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
  6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
  7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
  8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
  9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
  2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
  3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
  4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

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5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

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

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
  1. Install pipe insulation to outer diameter of pipe flange.
  2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
  4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
  1. Install mitered sections of pipe insulation.
  2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
  1. Install preformed valve covers manufactured of same material as pipe insulation when available.
  2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  3. Install insulation to flanges as specified for flange insulation application.
  4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

### **3.7 INSTALLATION OF MINERAL-FIBER INSULATION**

- A. Insulation Installation on Straight Pipes and Tubes:
  1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.

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4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

### 3.8 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 PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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- C. 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

### **3.9 FINISHES**

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Do not field paint aluminum or stainless-steel jackets.

### **3.10 PIPING INSULATION SCHEDULE, GENERAL**

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

### **3.11 INDOOR PIPING INSULATION SCHEDULE**

- A. Condensate and Equipment Drain Water below 60 Deg F:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 1/2 inch thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
- B. Chilled Water, above 40 Deg F:
  - 1. NPS 12 and Smaller: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 1 inch thick.
    - b. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inch thick.
- C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
  - 1. NPS 4 thru NPS 8: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.
  - 2. NPS 1-1/2 thru NPS 3: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inch thick.
  - 3. NPS 1 and Smaller: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
- D. Refrigerant Suction and Hot-Gas Piping:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 1 inch thick.

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- E. Low Pressure Steam Supply, 250 Deg F and Below:
  - 1. NPS 1-1/2 and Smaller: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.
  - 2. NPS 6 thru NPS 2: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches thick.
- F. Low Pressure Condensate Return, 200 Deg F and Below:
  - 1. NPS 1-1/2 and Smaller: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches thick.
  - 2. NPS 4 thru NPS 2: Insulation shall be one of the following:
    - a. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches thick.

**3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

- A. Refrigerant Suction and Hot-Gas Piping:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 1 inches thick.

**3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE**

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
  - 1. None.
- D. Piping, Exposed:
  - 1. PVC Jackets shall be provided on all piping exposed to public view. Exception: In gymnasiums all piping located 20'-0" AFF, PVC Jackets are not required.
  - 2. In addition, all piping in other areas (i.e. Mechanical Rooms, Janitor's Closet, Storage Rooms, Etc.) below 7'-0" AFF exposed to damage from traffic/normal operations shall have PVC jackets.
  - 3. PVC: 20 mils thick.

**3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE**

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Exposed:
  - 1. PVC: 20 mils thick.
  - 2. Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.020 inch thick.

**END OF SECTION 23 0719**





**SECTION 23 0800**

**COMMISSIONING OF HVAC**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
  - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

**1.3 ALLOWANCES**

- A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

**1.4 UNIT PRICES**

- A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

**1.5 CONTRACTOR'S RESPONSIBILITIES**

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meeting.
- C. Attend testing, adjusting, and balancing review and coordination meeting.
- D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

## **1.6 CxA'S RESPONSIBILITIES**

- A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Direct commissioning testing.
- C. Verify testing, adjusting, and balancing of Work are complete.
- D. Provide test data, inspection reports, and certificates in Systems Manual.

## **1.7 COMMISSIONING DOCUMENTATION**

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
  - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
  - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
  - 3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
  - 4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
  - 5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
  - 6. Test and inspection reports and certificates.
  - 7. Corrective action documents.
  - 8. Verification of testing, adjusting, and balancing reports.

## **1.8 SUBMITTALS**

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

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

## **PART 3 - EXECUTION**

### **3.1 TESTING PREPARATION**

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

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- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

### **3.2 TESTING AND BALANCING VERIFICATION**

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
  - 1. The CxA will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
  - 2. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
  - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
  - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

### **3.3 GENERAL TESTING REQUIREMENTS**

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

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- D. The CxA along with the HVAC&R Subcontractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

**3.4 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES**

- A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- B. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC&R Subcontractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
  - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
  - 2. Description of equipment for flushing operations.
  - 3. Minimum flushing water velocity.
  - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- C. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

**END OF SECTION 23 0800**

**SECTION 23 0923**

**DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Extend Existing System:
  - 1. Extend the existing Tridium BAS for this project.
  - 2. All controllers and accessories shall interface with the existing Tridium BAS.
- B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS) using Direct Digital Controls as shown on the drawings and as described herein.
- C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.
- D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.
- E. Related Requirements:
  - 1. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
  - 2. Communications Cabling:
    - a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
    - b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
  - 3. Raceways:
    - a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
    - b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.

4. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.
5. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

### 1.3 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
  1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
  2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
  3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
  4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
  5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.
- D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
- F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- G. COV: Changes of value.
- H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

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- J. DOCSIS: Data-Over Cable Service Interface Specifications.
- K. E/P: Voltage to pneumatic.
- L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- M. HLC: Heavy load conditions.
- N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- O. I/P: Current to pneumatic.
- P. LAN: Local area network.
- Q. LNS: LonWorks Network Services.
- R. 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.
- S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- T. Modbus TCP/IP: An open protocol for exchange of process data.
- U. MS/TP: Master-slave/token-passing, IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- V. MTBF: Mean time between failures.
- W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.
- X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- Z. POT: Portable operator's terminal.
- AA. PUE: Performance usage effectiveness.
- BB. RAM: Random access memory.

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- CC. RF: Radio frequency.
- DD. Router: Device connecting two or more networks at network layer.
- EE. Server: Computer used to maintain system configuration, historical and programming database.
- FF. TCP/IP: Transport control protocol/Internet protocol.
- GG. UPS: Uninterruptible power supply.
- HH. USB: Universal Serial Bus.
- II. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- JJ. VAV: Variable air volume.
- KK. WLED: White light emitting diode.

#### **1.4 ACTION SUBMITTALS**

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  3. Product description with complete technical data, performance curves, and product specification sheets.
  4. Installation, operation and maintenance instructions including factors effecting performance.
  5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
- a. Workstations.



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- b. Servers (if required)
  - c. Printers.
  - d. Routers.
  - e. DDC controllers.
  - f. Enclosures.
  - g. Electrical power devices.
  - h. UPS units.
  - i. Accessories.
  - j. Instruments.
  - k. Control dampers and actuators.
  - l. Control valves and actuators.
- 6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
  - 7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

- 1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway and DDC controller.
- 2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
- 3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
- 4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
- 5. Listing and description of each engineering equation used with reference source.
- 6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
- 7. Description of operator interface to alphanumeric and graphic programming.
- 8. Description of each network communication protocol.
- 9. Description of system database, including all data included in database, database capacity and limitations to expand database.
- 10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
- 11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. Shop Drawings:

- 1. General Requirements:
  - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
  - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
  - c. Drawings Size: 11" x 17".

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2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:
  - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
  - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
  - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
  - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
  - e. Network communication cable and raceway routing.
  - f. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
6. Schematic drawings for each controlled HVAC system indicating the following:
  - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
  - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
  - c. A graphic showing location of control I/O in proper relationship to HVAC system.
  - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
  - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
  - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
  - g. Narrative sequence of operation.
  - h. Graphic sequence of operation, showing all inputs and output logical blocks.
7. Control panel drawings indicating the following:
  - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
  - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
  - c. Front, rear, and side elevations and nameplate legend.
  - d. Unique drawing for each panel.
8. DDC system network riser diagram indicating the following:
  - a. Each device connected to network with unique identification for each.
  - b. Interconnection of each different network in DDC system.

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- c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
  - d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
- 9. DDC system electrical power riser diagram indicating the following:
  - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
  - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
  - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
  - d. Power wiring type and size, race type, and size for each.
- 10. Monitoring and control signal diagrams indicating the following:
  - a. Control signal cable and wiring between controllers and I/O.
  - b. Point-to-point schematic wiring diagrams for each product.
  - c. Control signal tubing to sensors, switches and transmitters.
  - d. Process signal tubing to sensors, switches and transmitters.
  - e. Pneumatic main air and control signal tubing to pneumatic damper and valve actuators, pilot-positioners if applicable, and associated transducers.
- 11. Color graphics completed by Owner.

E. System Description:

- 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
- 2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
- 3. System and product operation under each potential failure condition including, but not limited to, the following:
  - a. Loss of power.
  - b. Loss of network communication signal.
  - c. Loss of controller signals to inputs and outputs.
  - d. Operator workstation failure.
  - e. Server failure.
  - f. Gateway failure.
  - g. Network failure.
  - h. Controller failure.
  - i. Instrument failure.
  - j. Control damper and valve actuator failure.
- 4. Complete bibliography of documentation and media to be delivered to Owner.
- 5. Description of testing plans and procedures.

6. Description of Owner training.

## **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
  1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
    - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
    - c. As-built versions of submittal Product Data.
    - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
    - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
    - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    - g. Engineering, installation, and maintenance manuals that explain how to:
      - 1) Design and install new points, panels, and other hardware.
      - 2) Perform preventive maintenance and calibration.
      - 3) Debug hardware problems.
      - 4) Repair or replace hardware.
    - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
    - i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
    - j. List of recommended spare parts with part numbers and suppliers.
    - k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
    - l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
    - m. Licenses, guarantees, and warranty documents.
    - n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
    - o. Owner training materials.

## **1.6 QUALITY ASSURANCE**

- A. DDC System Manufacturer Qualifications:

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1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least five past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:
  - a. Product research and development.
  - b. Product and application engineering.
  - c. Product manufacturing, testing and quality control.
  - d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
  - e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 30 miles of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

## 1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
  - a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 DDC SYSTEM MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Tridium Controls
  2. Distech Controls

### **2.2 DDC SYSTEM DESCRIPTION**

- A. The entire BAS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to JACE. Building Automation System products shall be as specified below.
- B. Rockford Public Schools shall furnish and install a JACE Controller within each facility. The JACE shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.
- C. Provide materials and labor necessary to connect factory supplied control components.
- D. Provide central and remote hardware, software, and interconnecting wire and conduit.
- E. The BAS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

### **2.3 WEB ACCESS**

- A. DDC system shall be Web based.
1. Web-Based Access to DDC System:
    - a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
    - b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
    - c. Web access shall be password protected.

## 2.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.
  - 1. System Performance Objectives:
    - a. DDC system shall manage HVAC systems.
    - b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
    - c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
    - d. DDC system shall operate while unattended by an operator and through operator interaction.
    - e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.
- B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - 1. Flame-Spread Index: 25 or less.
  - 2. Smoke-Developed Index: 50 or less.
- C. DDC System Speed:
  - 1. Response Time of Connected I/O:
    - a. AI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
    - b. BI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
    - c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
    - d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
  - 2. Display of Connected I/O:
    - a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
    - b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
    - c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.

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- d. Graphic display refresh shall update within four seconds.
  - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
- D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.
- E. DDC System Data Storage:
  - 1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
  - 2. Local Storage:
    - a. Provide server workstation with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.
- F. DDC Data Access:
  - 1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
  - 2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
- G. Future Expandability:
  - 1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
  - 2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
  - 3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
- H. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
  - 1. Energy:
    - a. Thermal: Within 3 percent of reading.
    - b. Electric Power: Within 1 percent of reading.
    - c. Requirements indicated on Drawings for meters not supplied by utility.
  - 2. Flow:



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- a. Air: Within 2 percent of design flow rate.
  - b. Air (Terminal Units): Within 5 percent of design flow rate.
  - c. Water: Within 5 percent of design flow rate.
- 3. Gas:
  - a. Carbon Dioxide: Within 50 ppm.
  - b. Carbon Monoxide: Within 5 percent of reading.
  - c. Refrigerant: Within 50 ppm.
- 4. Moisture (Relative Humidity):
  - a. Air: Within 2 percent RH.
  - b. Space: Within 2 percent RH.
  - c. Outdoor: Within 2 percent RH.
- 5. Level: Within 2 percent of reading.
- 6. Pressure:
  - a. Air, Ducts and Equipment: 1 percent of instrument range.
  - b. Space: Within 1 percent of instrument range.
  - c. Water: Within 1 percent of instrument range.
- 7. Speed: Within 5 percent of reading.
- 8. Temperature, Dew Point:
  - a. Air: Within 1 deg F.
  - b. Space: Within 1 deg F.
  - c. Outdoor: Within 2 deg F.
- 9. Temperature, Dry Bulb:
  - a. Air: Within 1 deg F.
  - b. Space: Within 1 deg F.
  - c. Outdoor: Within 2 deg F.
  - d. Chilled Water: Within 1 deg F.
  - e. Condenser Water: Within 1 deg F.
  - f. Heating Hot Water: Within 1 deg F.
  - g. Energy Recovery Runaround Liquid: Within 1 deg F.
  - h. Temperature Difference: Within 0.25 deg F.
  - i. Other Temperatures Not Indicated: Within 1 deg F.
- 10. Temperature, Wet Bulb:
  - a. Air: Within 1 deg F.
  - b. Space: Within 1 deg F.
  - c. Outdoor: Within 2 deg F.
- I. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

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1. Current:
  - a. Milliamperes: Nearest 1/100th of a milliampere.
  - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2. Energy:
  - a. Electric Power:
    - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
    - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
    - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
  - b. Thermal, Rate:
    - 1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
    - 2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
  - c. Thermal, Usage:
    - 1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.
    - 2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.
3. Flow:
  - a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
  - b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
  - c. Steam: Nearest 1/10th lb/hr through 100 lbs/hr; nearest lbs/hr between 100 and 1000 lbs/hr; nearest 10 lbs/hr above 1000 lbs/hr.
4. Gas:
  - a. Carbon Dioxide (ppm): Nearest ppm.
  - b. Carbon Monoxide (ppm): Nearest ppm.

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- c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
    - d. Refrigerant (ppm): Nearest ppm.
  - 5. Moisture (Relative Humidity):
    - a. Relative Humidity (Percentage): Nearest 1 percent.
  - 6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
  - 7. Speed:
    - a. Rotation (rpm): Nearest 1 rpm.
    - b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
  - 8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
  - 9. Pressure:
    - a. Air, Ducts and Equipment: Nearest 1/10th in. w.c..
    - b. Space: Nearest 1/100th in. w.c..
    - c. Steam: Nearest 1/10th psig through 100 psig; nearest psig above 100 psig.
    - d. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.
  - 10. Temperature:
    - a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    - b. Outdoor: Nearest degree.
    - c. Space: Nearest 1/10th of a degree.
    - d. Chilled Water: Nearest 1/10th of a degree.
    - e. Condenser Water: Nearest 1/10th of a degree.
    - f. Heating Hot Water: Nearest degree.
    - g. Heat Recovery Runaround: Nearest 1/10th of a degree.
    - h. Steam: Nearest degree.
  - 11. Vibration: Nearest 1/10th in/s.
  - 12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.
- J. Control Stability: Control variables indicated within the following limits:
- 1. Flow:
    - a. Air, Ducts and Equipment, except Terminal Units: Within 2 percent of design flow rate.
    - b. Air, Terminal Units: Within 5 percent of design flow rate.
    - c. Water: Within 2 percent of design flow rate.
  - 2. Gas:
    - a. Carbon Dioxide: Within 50 ppm.
    - b. Carbon Monoxide: Within 5 percent of reading.
    - c. Oxygen: Within 5 percent of reading.

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3. Moisture (Relative Humidity):
    - a. Air: Within 2 percent RH.
    - b. Space: Within 2 percent RH.
    - c. Outdoor: Within 2 percent RH.
  4. Level: Within 5 percent of reading.
  5. Pressure:
    - a. Air, Ducts and Equipment: 1 percent of instrument range.
    - b. Space: Within 1 percent of instrument range.
    - c. Water: Within 1 percent of instrument range.
    - d. Steam: Within 1 percent of instrument range.
  6. Temperature, Dew Point:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
  7. Temperature, Dry Bulb:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
    - c. Chilled Water: Within 1 deg F.
    - d. Condenser Water: Within 1 deg F.
    - e. Heating Hot Water: Within 1 deg F.
  8. Temperature, Wet Bulb:
    - a. Air: Within 1 deg F.
    - b. Space: Within 1 deg F.
- K. Environmental Conditions for Controllers, Gateways, and Routers:
1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
    - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
  2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
    - a. Outdoors, Protected: Type 12.
    - b. Outdoors, Unprotected: Type 4.

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- c. Indoors, Heated with Filtered Ventilation: Type 1.
- d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
- e. Indoors, Heated and Air Conditioned: Type 1.
- f. Mechanical Equipment Rooms:
  - 1) Chiller and Boiler Rooms: Type 1.
  - 2) Air-Moving Equipment Rooms: Type 1.
- g. Localized Areas Exposed to Washdown: Type 4.
- h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 1.
- i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

L. Environmental Conditions for Instruments and Actuators:

- 1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
  - a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.
- 2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
  - a. Outdoors, Protected: Type 1.
  - b. Outdoors, Unprotected: Type 4.
  - c. Indoors, Heated with Filtered Ventilation: Type 1.
  - d. Indoors, Heated with Non-Filtered Ventilation: Type 2.
  - e. Indoors, Heated and Air-conditioned: Type 1.
  - f. Mechanical Equipment Rooms:
    - 1) Chiller and Boiler Rooms: Type 1.
    - 2) Air-Moving Equipment Rooms: Type 1.
  - g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 1.
  - h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

M. DDC System Reliability:

- 1. Design, install and configure DDC controllers, gateways, routers, and to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value shall include any failure for any reason to any part of products indicated.

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2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

N. Electric Power Quality:

1. Power-Line Surges:

- a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
- b. Do not use fuses for surge protection.
- c. Test protection in the normal mode and in the common mode, using the following two waveforms:
  - 1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
  - 2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

- a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
  - 1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
  - 2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
  - 3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
  - 4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.
3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

O. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

P. UPS:

1. DDC system products powered by UPS units shall include the following:
  - a. Desktop workstations.
  - b. Printers.

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- c. Servers.
- d. Gateways.
- e. DDC controllers, except application-specific controllers.

Q. Continuity of Operation after Electric Power Interruption:

- 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

## 2.5 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two or three levels of LANs.

- 1. Level one LAN shall connect network controllers and operator workstations.
- 2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
- 3. Level two or Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.
- 4. Level two or Level three LAN shall connect application-specific controllers to application-specific controllers.

B. Minimum Data Transfer and Communication Speed:

- 1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
- 2. LAN Connecting Programmable Application Controllers: 1000 kbps.
- 3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

## **2.6 DDC SYSTEM OPERATOR INTERFACES**

- A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
  - 1. Desktop and portable workstation with hardwired connection through LAN port.
  - 2. Portable operator terminal with hardwired connection through LAN port.
  - 3. Portable operator workstation with wireless connection through LAN router.
  - 4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
  - 5. Remote connection through web access.
- B. Access to system, regardless of operator means used, shall be transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
  - 1. Each mechanical equipment room.
  - 2. Each boiler room.
  - 3. Each chiller room or outdoor chiller yard.
  - 4. Each cooling tower location.
  - 5. Each different roof level with roof-mounted air-handling units or rooftop units.
- D. Desktop Workstations:
  - 1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
  - 2. Able to communicate with any device located on any DDC system LAN.
- E. Portable Workstations:
  - 1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
  - 2. Able to communicate with any device located on any DDC system LAN.
  - 3. Connect to DDC system Level two or Level three LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
  - 4. Connect to system through a wireless router connected to Level one LAN.
  - 5. Connect to system through a cellular data service.
  - 6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
  - 7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
  - 8. Have dynamic graphic displays that are identical to desktop workstations.
- F. POT:
  - 1. Connect DDC controller through a communications port local to controller.



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2. Able to communicate with any DDC system controller that is directly connected or connected to DDC system.
- G. Mobile Device:
1. Connect to system through a wireless router connected to LAN and cellular data service.
  2. Able to communicate with any DDC controller connected to DDC system using a dedicated application and secure web access.
- H. Critical Alarm Reporting:
1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
  2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
  3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.
- I. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

## **2.7 NETWORKS**

- A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
1. ATA 878.1, ARCNET.
  2. CEA-709.1-C.
  3. IP.
  4. IEEE 8802-3, Ethernet.
- B. Acceptable networks for connecting programmable application controllers include the following:
1. ATA 878.1, ARCNET.
  2. CEA-709.1-C.
  3. IP.
  4. IEEE 8802-3, Ethernet.
- C. Acceptable networks for connecting application-specific controllers include the following:
1. ATA 878.1, ARCNET.
  2. CEA-709.1-C.
  3. EIA-485A.
  4. IP.
  5. IEEE 8802-3, Ethernet.

## **2.8 NETWORK COMMUNICATION PROTOCOL**

- A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.
- B. ASHRAE 135 Protocol:
  - 1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
  - 2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
  - 3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
  - 4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

## **2.9 SYSTEM SOFTWARE**

- A. System Software Minimum Requirements:
  - 1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
  - 2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
  - 3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
  - 4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
  - 5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
  - 6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.
- B. Operator Interface Software:
  - 1. Minimize operator training through use of English language prorating and English language point identification.
  - 2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
  - 3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.

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4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
  - a. Operator access to DDC system shall be under password control.
  - b. An alphanumeric password shall be field assignable to each operator.
  - c. Operators shall be able to access DDC system by entry of proper password.
  - d. Operator password shall be same regardless of which computer or other interface means is used.
  - e. Additions or changes made to passwords shall be updated automatically.
  - f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
  - g. Software shall have at least five access levels.
  - h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
  - i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
7. Data Segregation:
  - a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
  - b. Include at least 32 segregation groups.
  - c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
  - d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
  - e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
  - f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
8. Operators shall be able to perform commands including, but not limited to, the following:
  - a. Start or stop selected equipment.
  - b. Adjust set points.
  - c. Add, modify, and delete time programming.
  - d. Enable and disable process execution.
  - e. Lock and unlock alarm reporting for each point.
  - f. Enable and disable totalization for each point.
  - g. Enable and disable trending for each point.
  - h. Override control loop set points.
  - i. Enter temporary override schedules.
  - j. Define holiday schedules.
  - k. Change time and date.
  - l. Enter and modify analog alarm limits.
  - m. Enter and modify analog warning limits.

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- n. View limits.
  - o. Enable and disable demand limiting.
  - p. Enable and disable duty cycle.
  - q. Display logic programming for each control sequence.
9. Reporting:
- a. Generated automatically and manually.
  - b. Sent to displays, printers and disk files.
  - c. Types of Reporting:
    - 1) General listing of points.
    - 2) List points currently in alarm.
    - 3) List of off-line points.
    - 4) List points currently in override status.
    - 5) List of disabled points.
    - 6) List points currently locked out.
    - 7) List of items defined in a "Follow-Up" file.
    - 8) List weekly schedules.
    - 9) List holiday programming.
    - 10) List of limits and deadbands.
10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.
- C. Graphic Interface Software:
- 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
  - 2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
  - 3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
  - 4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
  - 5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
  - 6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
  - 7. Graphics are to be online programmable and under password control.
  - 8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
  - 9. Graphics shall also contain software points.
  - 10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
  - 11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option

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- of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
  13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
  14. Include operator with means to directly access graphics without going through penetration path.
  15. Dynamic data shall be assignable to graphics.
  16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
  17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
  18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
  19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
    - a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    - c. Keyboard equivalent shall be available for those operators with that preference.
  20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
  21. Help Features:
    - a. On-line context-sensitive help utility to facilitate operator training and understanding.
    - b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
      - 1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
    - c. Available for Every Menu Item:
      - 1) Index items for each system menu item.
  22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
    - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.

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- b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
  - 1) Define background screens.
  - 2) Define connecting lines and curves.
  - 3) Locate, orient and size descriptive text.
  - 4) Define and display colors for all elements.
  - 5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

- 1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
- 2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
  - a. Room layouts with room identification and name.
  - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
  - c. Location and identification of each hardware point being controlled or monitored by DDC system.
- 3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
- 4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
- 5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.

E. Customizing Software:

- 1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
- 2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
- 3. As a minimum, include the following modification capability:
  - a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
  - b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
  - c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

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- d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
- e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
- f. Point related change capability shall include the following:
  - 1) System and point enable and disable.
  - 2) Run-time enable and disable.
  - 3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
  - 4) Assignment of alarm and warning limits.
- g. Application program change capability shall include the following:
  - 1) Enable and disable of software programs.
  - 2) Programming changes.
  - 3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.
- 4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
- 5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
- 6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
  - a. Proportional control (P).
  - b. Proportional plus integral (PI).
  - c. Proportional plus integral plus derivative (PID).
  - d. Adaptive and intelligent self-learning control.
    - 1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
    - 2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.
- 7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
- 8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
- 9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.

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10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:
  - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
  - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
  - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
  - d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.
5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.
  - a. Class 1:
    - 1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
    - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
    - 3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.
  - b. Class 2:
    - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
    - 2) Acknowledgement may be through a multiple alarm acknowledgment.
  - c. Class 3:
    - 1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
    - 2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
    - 3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.



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- 4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.
- d. Class 4:
  - 1) Routine maintenance or other types of warning alarms.
  - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.
- G. Reports and Logs:
  1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
  2. Each report shall be definable as to data content, format, interval and date.
  3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation server for historical reporting.
  4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
  5. Reports and logs shall be stored on workstation and server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
  6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
- H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
  1. All I/O: With current status and values.
  2. Alarm: All current alarms, except those in alarm lockout.
  3. Disabled I/O: All I/O points that are disabled.
  4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
  5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
  6. Logs:
    - a. Alarm history.
    - b. System messages.
    - c. System events.
    - d. Trends.
- I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- J. Tenant Override Reports: Prepare Project-specific reports.

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1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

K. HVAC Equipment Reports: Prepare Project-specific reports.

1. Chiller Report: Daily report showing operating conditions of each chiller according to ASHRAE 147, including, but not limited to, the following:
  - a. Chilled-water entering temperature.
  - b. Chilled-water leaving temperature.
  - c. Chilled-water flow rate.
  - d. Chilled-water inlet and outlet pressures.
  - e. Evaporator refrigerant pressure and temperature.
  - f. Condenser refrigerant pressure and liquid temperature.
  - g. Condenser-water entering temperature.
  - h. Condenser-water leaving temperature.
  - i. Condenser-water flow rate.
  - j. Refrigerant levels.
  - k. Oil pressure and temperature.
  - l. Oil level.
  - m. Compressor refrigerant discharge temperature.
  - n. Compressor refrigerant suction temperature.
  - o. Addition of refrigerant.
  - p. Addition of oil.
  - q. Vibration levels or observation that vibration is not excessive.
  - r. Motor amperes per phase.
  - s. Motor volts per phase.
  - t. Refrigerant monitor level (PPM).
  - u. Purge exhaust time or discharge count.
  - v. Ambient temperature (dry bulb and wet bulb).
  - w. Date and time logged.

L. Utility Reports: Prepare Project-specific reports.

1. Electric Report:
  - a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
  - b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
  - c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
  - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.
  - e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

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2. Natural Gas Report:

- a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
- b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
- c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
- d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
- e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

M. Energy Reports: Prepare Project-specific daily, weekly, monthly, annual and since-installed energy reports.

1. Prepare report for each purchased energy utility, indicating the following:

- a. Time period being reported with beginning and end date, and time indicated.
- b. Consumption in units of measure commonly used to report specific utility consumption over time.
- c. Gross area served by utility.
- d. Consumption per unit area served using utility-specific unit of measure.
- e. Cost per utility unit.
- f. Utility cost per unit area.
- g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
- h. Consumption per unit area using common unit of measure.

2. Prepare report for each renewable energy source, indicating the following:

- a. Time period being reported with beginning and end date, and time indicated.
- b. Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.
- c. Gross area served by renewable energy source.
- d. Harvested energy per unit area served using specific unit of measure.
- e. Cost per purchased utility unit displaced by renewable energy.
- f. Cost savings attributed to harvested energy source.
- g. Cost savings per unit area attributed to harvested energy.
- h. Convert all renewable energy sources to a common energy consumption unit of measure and report for each.
- i. Harvested energy per unit area using common unit of measure.

3. Prepare purchased energy utility report for each sub-metered area that indicates the following:

- a. Time period being reported with beginning and end date, and time indicated.
- b. Gross area served.
- c. Energy consumption by energy utility type.

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- d. Energy consumption per unit area by energy utility type.
  - e. Total energy consumption of all utilities in common units of measure.
  - f. Total energy consumption of all utilities in common units of measure per unit area.
  - g. Unit energy cost by energy utility type.
  - h. Energy cost by energy utility type.
  - i. Energy cost per unit area by energy utility type.
  - j. Total cost of all energy utilities.
  - k. Total cost of all energy utilities per unit area.
4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:
- a. Time period being reported with beginning and end date, and time indicated.
  - b. Gross area served.
  - c. Energy consumption by energy utility type.
  - d. Energy consumption per unit area by energy utility type.
  - e. Total energy consumption of all utilities in common units of measure.
  - f. Total energy consumption of all utilities in common units of measure per unit area.
  - g. Unit energy cost by energy utility type.
  - h. Energy cost by energy utility type.
  - i. Energy cost per unit area by energy utility type.
  - j. Total cost of all energy utilities.
  - k. Total cost of all energy utilities per unit area.
- N. HVAC System Efficiency Reports: Prepare Project-specific daily weekly monthly and annual, annual and since-installed HVAC system efficiency reports.
1. Prepare report for each chilled-water system, indicating the following:
- a. Time period being reported with beginning and end date, and time indicated.
  - b. Cooling energy supplied during time period.
  - c. Power energy consumed during time period by cooling equipment used to produce cooling energy supplied. List power consumed for each individual piece of equipment in system and summed total of all equipment in system.
  - d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
  - e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
  - f. Units of measure used in report shall be consistent with units indicated for system.
2. Prepare report for each hot-water system, indicating the following:
- a. Time period being reported with beginning and end date, and time indicated.
  - b. Heating energy supplied during time period.
  - c. Fuel consumed during time period by boilers used to produce heating energy supplied. List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.
  - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
  - e. Units of measure used in report shall be consistent with units indicated for system.

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O. Weather Reports:

1. Include daily report showing the following:
  - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
  - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
  - c. Daily minimum, maximum, and average outdoor dew point temperature.
  - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
  - e. Daily minimum, maximum, and average outdoor carbon dioxide level.
  - f. Daily minimum, maximum, and average relative humidity.
  - g. Daily minimum, maximum, and average barometric pressure.
  - h. Daily minimum, maximum, and average wind speed and direction.
2. Include weekly report showing the following:
  - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
  - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
  - c. Daily minimum, maximum, and average outdoor dew point temperature.
  - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
  - e. Weekly minimum, maximum, and average outdoor carbon dioxide level.
  - f. Daily minimum, maximum, and average relative humidity.
  - g. Daily minimum, maximum, and average barometric pressure.
  - h. Daily minimum, maximum, and average wind speed and direction.
3. Include monthly report showing the following:
  - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
  - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
  - c. Daily minimum, maximum, and average outdoor dew point temperature.
  - d. Number of heating degree-days for each day calculated from a base temperature of 55 deg F.
  - e. Monthly minimum, maximum, and average outdoor carbon dioxide level.
  - f. Daily minimum, maximum, and average relative humidity.
  - g. Daily minimum, maximum, and average barometric pressure.
  - h. Daily minimum, maximum, and average wind speed and direction.
4. Include annual (12-month) report showing the following:
  - a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
  - b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
  - c. Monthly minimum, maximum, and average outdoor dew point temperature.
  - d. Number of heating degree-days for each month calculated from a base temperature of 55 deg F.
  - e. Annual minimum, maximum, and average outdoor carbon dioxide level.
  - f. Monthly minimum, maximum, and average relative humidity.
  - g. Daily minimum, maximum, and average barometric pressure.
  - h. Daily minimum, maximum, and average wind speed and direction.

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P. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

Q. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

R. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be as follows:
  - a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
    - 1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
    - 2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
  - b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
  - c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

S. Database Management Software:

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1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
  - a. Backup.
  - b. Purge.
  - c. Restore.
4. Database management software shall support the following:
  - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
  - b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
  - c. Backup: Include means to create a database backup file and select a storage location.
  - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Database management software shall include information of current database activity, including the following:
  - a. Ready.
  - b. Purging record from a database.
  - c. Action failed.
  - d. Refreshing statistics.
  - e. Restoring database.
  - f. Shrinking a database.
  - g. Backing up a database.
  - h. Resetting Internet information services.
  - i. Starting network device manager.
  - j. Shutting down the network device manager.
  - k. Action successful.
6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:
  - a. Allow operator to set and review scan intervals and start times.
  - b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.

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- c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
  - d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
  - e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.
9. Monitoring settings taskbar shall include the following informational icons:
- a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
  - b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
  - c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

**2.10 ASHRAE 135 GATEWAYS**

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
  - 1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
  - 2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
  - 3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
  - 4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
  - 5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
  - 6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.



## **2.11 ASHRAE 135 PROTOCOL ANALYZER**

- A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.
- B. Analyzer shall include the following minimum capabilities:
  - 1. Capture and store to a file data traffic on all network levels.
  - 2. Measure bandwidth usage.
  - 3. Filtering options with ability to ignore select traffic.

## **2.12 DDC CONTROLLERS**

- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
- C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- E. Environment Requirements:
  - 1. Controller hardware shall be suitable for the anticipated ambient conditions.
  - 2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
  - 3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.
- F. Power and Noise Immunity:
  - 1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
  - 2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.
- G. DDC Controller Spare Processing Capacity:
  - 1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
    - a. Network Controllers: 50 percent.
    - b. Programmable Application Controllers: Not less than 60 percent.
    - c. Application-Specific Controllers: Not less than 70 percent.
  - 2. Memory shall support DDC controller's operating system and database and shall include the following:

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- a. Monitoring and control.
  - b. Energy management, operation and optimization applications.
  - c. Alarm management.
  - d. Historical trend data of all connected I/O points.
  - e. Maintenance applications.
  - f. Operator interfaces.
  - g. Monitoring of manual overrides.
- H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
- 1. Network Controllers:
    - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
    - b. Minimum Spare I/O Points per Controller:
      - 1) AIs: Two.
      - 2) AOs: Two.
      - 3) BIs: Three.
      - 4) BOs: Three.
  - 2. Programmable Application Controllers:
    - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
    - b. Minimum Spare I/O Points per Controller:
      - 1) AIs: Two.
      - 2) AOs: Two.
      - 3) BIs: Three.
      - 4) BOs: Three.
  - 3. Application-Specific Controllers:
    - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
    - b. Minimum Spare I/O Points per Controller:
      - 1) AIs: One.
      - 2) AOs: One.
      - 3) BIs: One.
      - 4) BOs: One.
- I. Maintenance and Support: Include the following features to facilitate maintenance and support:
- 1. Mount microprocessor components on circuit cards for ease of removal and replacement.
  - 2. Means to quickly and easily disconnect controller from network.
  - 3. Means to quickly and easily access connect to field test equipment.
  - 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.
- J. Input and Output Point Interface:

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1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:
  - a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
  - b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
  - c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
  - d. Signal conditioning including transient rejection shall be provided for each AI.
  - e. Capable of being individually calibrated for zero and span.
  - f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
5. AOs:
  - a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
  - b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
  - c. Capable of being individually calibrated for zero and span.
  - d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
6. BIs:
  - a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
  - b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
  - c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
  - d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
  - e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
7. BOs:
  - a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

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- 1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
  - 2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.
- 
- b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
  - c. BOs shall be selectable for either normally open or normally closed operation.
  - d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
  - e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

## **2.13 NETWORK CONTROLLERS**

### **A. General Network Controller Requirements:**

1. All network controllers shall be Tridium JACE furnish and installed by Rockford Public Schools.

## **2.14 PROGRAMMABLE APPLICATION CONTROLLERS**

### **A. General Programmable Application Controller Requirements:**

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

### **B. Communication:**

1. Programmable application controllers shall communicate with other devices on network.

### **C. Operator Interface:**

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1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
  2. Local Keypad and Display:
    - a. Equip controller with local keypad and digital display for interrogating and editing data.
    - b. Use of keypad and display shall require security password.
- D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
  2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
  3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

## **2.15 APPLICATION-SPECIFIC CONTROLLERS**

- A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
1. Capable of standalone operation and shall continue to include control functions without being connected to network.
  2. Data shall be shared between networked controllers and other network devices.
- B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.
- C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.
- D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
  2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
  3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

## **2.16 CONTROLLER SOFTWARE**

- A. General Controller Software Requirements:

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1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
  2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
  3. Control functions shall be executed within controllers using DDC algorithms.
  4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.
- B. Security:
1. Operator access shall be secured using individual security passwords and user names.
  2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
  3. Operator log-on and log-off attempts shall be recorded.
  4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.
- C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:
1. Weekly Schedule:
    - a. Include separate schedules for each day of week.
    - b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
    - c. Each schedule may consist of up to 10 events.
    - d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
  2. Exception Schedules:
    - a. Include ability for operator to designate any day of the year as an exception schedule.
    - b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
  3. Holiday Schedules:
    - a. Include capability for operator to define up to 99 special or holiday schedules.
    - b. Schedules may be placed on scheduling calendar and will be repeated each year.
    - c. Operator shall be able to define length of each holiday period.
- D. System Coordination:
1. Include standard application for proper coordination of equipment.
  2. Application shall include operator with a method of grouping together equipment based on function and location.
  3. Group may then be used for scheduling and other applications.

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E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:

1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:
  - a. Reset air-handling unit supply temperature set points.
  - b. Reset space temperature set points.
  - c. De-energize equipment based on priority.
4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:
  - a. Addition and deletion of loads controlled.
  - b. Changes in demand intervals.
  - c. Changes in demand limit for meter(s).
  - d. Maximum shutoff time for equipment.
  - e. Minimum shutoff time for equipment.

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- f. Select rotational or sequential shedding and restoring.
  - g. Shed and restore priority.
- 7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:
  - a. Total electric consumption.
  - b. Peak demand.
  - c. Date and time of peak demand.
  - d. Daily peak demand.
- J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- L. Control Loops:
  - 1. Support any of the following control loops, as applicable to control required:
    - a. Two-position (on/off, open/close, slow/fast) control.
    - b. Proportional control.
    - c. Proportional plus integral (PI) control.
    - d. Proportional plus integral plus derivative (PID) control.
      - 1) Include PID algorithms with direct or reverse action and anti-windup.
      - 2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
      - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
    - e. Adaptive (automatic tuning).
- M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
- N. Energy Calculations:
  - 1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
  - 2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
  - 3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.
- O. Anti-Short Cycling:
  - 1. BO points shall be protected from short cycling.



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2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

## 2.17 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
6. Individual wall-mounted double-door enclosures shall not exceed 60 inches wide and 36 inches high.
7. Freestanding enclosures shall not exceed 48 inches wide and 72 inches high.
8. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
9. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.

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9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:
  - a. Enclosure size less than 24 in.: 0.053 in. or 0.067 in. thick.
  - b. Enclosure size 24 in. and larger: 0.067 in. or 0.093 in. thick.
3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
  - a. Exterior color shall be ANSI 61 gray.
  - b. Interior color shall be ANSI 61 gray.
4. Hinged door full size of front face of enclosure and supported using:

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- a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
    - b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.
  - 5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    - a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
    - b. Size 24 in. and larger: Solid aluminum, 0.10 in. or steel, 0.093 in. thick.
  - 6. Internal panel mounting hardware, grounding hardware and sealing washers.
  - 7. Grounding stud on enclosure body.
  - 8. Thermoplastic pocket on inside of door for record Drawings and Product Data.
- E. Wall Mounted NEMA 250, Types 4 and 12:
- 1. Enclosure shall be NRTL listed according to UL 508A.
  - 2. Seam and joints are continuously welded and ground smooth.
  - 3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
  - 4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
  - 5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
  - 6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
  - 7. Construct enclosure of steel, not less than the following:
    - a. Size Less Than 24 Inches: 0.053 inch or 0.067 inch thick.
    - b. Size 24 Inches and Larger: 0.067 inch thick.
  - 8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    - a. Exterior color shall be ANSI 61 gray.
    - b. Interior color shall be ANSI 61 gray.
  - 9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
    - a. Sizes through 24 Inches Tall: Two hinges.
    - b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
    - c. Sizes Larger 48 Inches Tall: Four hinges.
  - 10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
    - a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
  - 11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    - a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.

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- b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.
- 12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
- 13. Grounding stud on enclosure body.
- 14. Thermoplastic pocket on inside of door for record Drawings and Product Data.
- F. Freestanding, NEMA 250, Type 1:
  - 1. Enclosure shall be NRTL listed according to UL 508A.
  - 2. Seam and joints are continuously welded and ground smooth.
  - 3. Externally formed body flange around perimeter of enclosure face.
  - 4. Single-door enclosure sizes up to 84 inches tall by 36 inches wide.
  - 5. Double-door enclosure sizes up to 84 inches tall by 72 inches wide.
  - 6. Construct enclosure of steel, not less than 0.067 inch thick.
  - 7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    - a. Exterior color shall be ANSI 61 gray.
    - b. Interior color shall be ANSI 61 gray.
  - 8. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
  - 9. Double-door enclosures with overlapping door design to include unobstructed full-width access.
  - 10. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
  - 11. Removable back covers.
  - 12. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
  - 13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
  - 14. Grounding stud on enclosure body.
  - 15. Thermoplastic pocket on inside of door for record Drawings and Product Data.
  - 16. Nominal 4-inch-tall integral lifting base, not less than 0.123 inch thick, with predrilled holes for attachment to mounting surface.
  - 17. Each top end of enclosure fitted with lifting tabs, not less than 0.172 inch thick.
  - 18. Internal rack-mount shelves and angles as required by application.
- G. Freestanding, NEMA 250, Types 4 and 12:
  - 1. Enclosure shall be NRTL listed according to UL 508A.
  - 2. Seam and joints are continuously welded and ground smooth.
  - 3. Externally formed body flange around perimeter of enclosure face.
  - 4. Type 12 Enclosure Sizes:
    - a. Single-door enclosure sizes up to 90 inches tall by 36 inches wide.
    - b. Double-door enclosure sizes up to 90 inches tall by 72 inches wide.
  - 5. Type 4 Enclosure Sizes:
    - a. Single-door enclosure sizes up to 72 inches tall by 36 inches wide.
  - 6. Construct enclosure of steel, not less than 0.093 inch thick.

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7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
  - a. Exterior color shall be ANSI 61 gray.
  - b. Interior color shall be ANSI 61 gray.
8. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.
10. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.
14. Top of enclosure fitted with no fewer than two lifting eyes.
15. Internal rack-mount shelves and angles as required by application.

## **2.18 RELAYS**

### **A. General-Purpose Relays:**

1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Relays shall have LED indication and a manual reset and push-to-test button.
7. Performance:
  - a. Mechanical Life: At least 10 million cycles.
  - b. Electrical Life: At least 100,000 cycles at rated load.
  - c. Pickup Time: 15 ms or less.
  - d. Dropout Time: 10 ms or less.
  - e. Pull-in Voltage: 85 percent of rated voltage.
  - f. Dropout Voltage: 50 percent of nominal rated voltage.
  - g. Power Consumption: 2 VA.
  - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

### **B. Multifunction Time-Delay Relays:**

1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.

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3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:
  - a. Mechanical Life: At least 10 million cycles.
  - b. Electrical Life: At least 100,000 cycles at rated load.
  - c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
  - d. Repeatability: Within 2 percent.
  - e. Recycle Time: 45 ms.
  - f. Minimum Pulse Width Control: 50 ms.
  - g. Power Consumption: 5 VA or less at 120-V ac.
  - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:
  - a. Mechanical Life: At least 10 million cycles.
  - b. Electrical Life: At least 100,000 cycles at rated load.
  - c. Pickup Time: 15 ms or less.
  - d. Dropout Time: 10 ms or less.
  - e. Pull-in Voltage: 85 percent of rated voltage.
  - f. Dropout Voltage: 50 percent of nominal rated voltage.
  - g. Power Consumption: 2 VA.
  - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.

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7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.
- E. Combination On-Off Status Sensor and On-Off Relay:
  1. Description:
    - a. On-off control and status indication in a single device.
    - b. LED status indication of activated relay and current trigger.
    - c. Closed-Open-Auto override switch located on the load side of the relay.
  2. Performance:
    - a. Ambient Temperature: Minus 30 to 140 deg F.
    - b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.
  3. Status Indication:
    - a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
    - b. Current Sensor Range: As required by application.
    - c. Current Set Point: Adjustable.
    - d. Current Sensor Output:
      - 1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
      - 2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
      - 3) Analog, zero- to 5- or 10-V dc.
      - 4) Analog, 4 to 20 mA, loop powered.
  4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
  5. Enclosure: NEMA 250, Type 1 enclosure.

## 2.19 ELECTRICAL POWER DEVICES

- A. Transformers:
  1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
  2. Transformer shall have both primary and secondary fuses.
- B. Power-Line Conditioner:
  1. General Power-Line Conditioner Requirements:
    - a. Design to ensure maximum reliability, serviceability and performance.
    - b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

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2. Standards: NRTL listed per UL 1012.
3. Performance:
  - a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
  - b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
    - 1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
    - 2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
    - 3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
  - c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
  - d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
  - e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
  - f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
  - g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
  - h. Attenuate load-generated odd current harmonics 23 dB at the input.
  - i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
  - j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
  - k. Common-mode noise attenuation of 140 dB.
  - l. Transverse-mode noise attenuation of 120 dB.
  - m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
  - n. Reliability of 200,000 hours' MTBF.
  - o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
  - p. Approximately 92 percent efficient at full load.
4. Transformer Construction:
  - a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.



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- b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
  - c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
  - d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
  - e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
  - f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
  - g. Include interface terminals for output power hot, neutral and ground conductors.
  - h. Label leads, wires and terminals to correspond with circuit wiring diagram.
  - i. Vacuum impregnate transformer with epoxy resin.
- 5. Cabinet Construction:
  - a. Design for panel or floor mounting.
  - b. NEMA 250, Type 1, general-purpose, indoor enclosure.
  - c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
  - d. Include a textured baked-on paint finish.
- C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:
  - 1. The maximum continuous operating voltage shall be at least 125 percent.
  - 2. The operating frequency range shall be 47 to 63 Hz.
  - 3. Protection modes according to NEMA LS-1.
  - 4. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:
    - a. Line to Neutral: 45,000 A.
    - b. Neutral to Ground: 45,000 A.
    - c. Line to Ground: 45,000 A.
    - d. Per Phase: 90,000 A.
  - 5. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:
    - a. Line to Neutral: 360 V.
    - b. Line to Ground: 360 V.
    - c. Neutral to Ground: 360 V.
  - 6. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.
    - a. Line to Neutral:
      - 1) 100 kHz: 42 dB.
      - 2) 1 MHz: 25 dB.
      - 3) 10 MHz: 21 dB.
      - 4) 100 MHz: 36 dB.
    - b. Line to Ground:

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- 1) 100 kHz: 16 dB.
  - 2) 1 MHz: 55 dB.
  - 3) 10 MHz: 81 dB.
  - 4) 100 MHz: 80 dB.
7. Unit shall have LED status indicator that extinguishes to indicate a failure.
  8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
  9. Unit shall not generate any appreciable magnetic field.
  10. Unit shall not generate an audible noise.
- D. DC Power Supply:
1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
  2. Enclose circuitry in a housing.
  3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
  4. Performance:
    - a. Output voltage nominally 25-V dc within 5 percent.
    - b. Output current up to 100 mA.
    - c. Input voltage nominally 120-V ac, 60 Hz.
    - d. Load regulation within 0.5 percent from zero- to 100-mA load.
    - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
    - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

## **2.20 CONTROL WIRE AND CABLE**

- A. Wire: Single conductor control wiring above 24 V.
1. Wire size shall be at least No. 18 AWG.
  2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
  3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
  4. Conductor colors shall be black (hot), white (neutral), and green (ground).
  5. Furnish wire on spools.
- B. Single Twisted Shielded Instrumentation Cable above 24 V:
1. Wire size shall be a minimum No. 20 AWG.
  2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
  3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
  4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
  5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
  6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
  7. Furnish wire on spools.

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C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Section 260523 "Control-Voltage Electrical Power Cables and Section 271513 "Communications Copper Horizontal Cabling."
  - a. Cable shall be plenum rated.
  - b. Cable shall have a unique color that is different from other cables used on Project.

## 2.21 RACEWAYS

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables and optical fiber cables.

## 2.22 ACCESSORIES

A. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig.
3. Differential adjustable from 2 to 6 psig.
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

B. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.

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3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

C. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

D. Manual Valves:

1. Needle Type:
  - a. PTFE packing.
  - b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
  - c. Aluminum T-bar handle.
  - d. Include tubing connections.
2. Ball Type:
  - a. Body: Bronze ASTM B 62 or ASTM B 61.
  - b. Ball: Type 316 stainless steel.
  - c. Stem: Type 316 stainless steel.
  - d. Seats: Reinforced PTFE.
  - e. Packing Ring: Reinforced PTFE.
  - f. Lever: Stainless steel with a vinyl grip.
  - g. 600 WOG.
  - h. Threaded end connections.

## 2.23 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label bearing unique identification.
  - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size shall be as follows:
  - a. Operator Workstations: Minimum of 0.5 inch high.

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- b. Servers: Minimum of 0.5 inch high.
  - c. Printers: Minimum of 0.5 inch high.
  - d. DDC Controllers: Minimum of 0.5 inch high.
  - e. Gateways: Minimum of 0.5 inch high.
  - f. Repeaters: Minimum of 0.5 inch high.
  - g. Enclosures: Minimum of 0.5 inch high.
  - h. Electrical Power Devices: Minimum of 0.25 inch high.
  - i. UPS units: Minimum of 0.5 inch high.
  - j. Accessories: Minimum of 0.25 inch high.
  - k. Instruments: Minimum of 0.25 inch high.
  - l. Control Damper and Valve Actuators: Minimum of 0.25 inch high.
3. Legend shall consist of white lettering on black background.
  4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
  5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."

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4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
  1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
  1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
  2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT**

- A. Communication Interface to Equipment with Integral Controls:
  1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
  2. Equipment to Be Connected:
    - a. Air-terminal units specified in Section 233600 "Air Terminal Units."
    - b. Boilers specified in Section 235216 "Condensing Boilers."
    - c. Chillers specified in Section 236423.13 "Air-Cooled, Scroll Water Chillers."
    - d. Heat wheels and heat exchangers specified in Section 237223 "Air-to-Air Energy Recovery Equipment."
    - e. Air-handling units specified in Section 237313 "Modular Indoor Central-Station Air-Handling Units."
    - f. Roof-top units specified in Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units."
    - g. Dedicated outdoor-air units specified in Section 237433 "Dedicated Outdoor-Air Units."
    - h. Computer-room air-conditioning units specified in Section 238123.11 "Small-Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor Mounted Units."

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- i. Computer-room air-conditioning units specified in Section 238123.13 "Computer-Room Air Conditioners, Ceiling-Mounted Units."
- j. Computer-room air-conditioning units specified in Section 238123.14 "Computer-Room Air Conditioners, Console Units."
- k. Computer-room, rack-mounted cooling equipment specified in Section 238123.18 "Computer-Room, Rack-Cooling Equipment."
- l. Fan-coil units specified in Section 238219 "Fan Coil Units."
- m. Unit ventilators specified in Section 238223 "Unit Ventilators."
- n. Motor-control centers specified in Section 262419 "Motor-Control Centers."
- o. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."

B. Communication Interface to Other Building Systems:

- 1. DDC system shall have a communication interface with systems having a communication interface.
- 2. Systems to Be Connected:
  - a. Power monitoring specified in Section 260913 "Electrical Power Monitoring and Control."
  - b. Lighting controls specified in Section 260926 "Lighting Control Panelboards."
  - c. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."
  - d. Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."
  - e. Fire-alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems."
  - f. Fire-alarm system specified in Section 284621.13 "Conventional Fire-Alarm Systems."

### 3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
  - 1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
  - 2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
  - 3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
  - 1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
  - 2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."

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3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
5. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 230923.27 "Temperature Instruments."

### **3.4 GENERAL INSTALLATION REQUIREMENTS**

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a 50lb force.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
- H. Welding Requirements:
  1. Restrict welding and burning to supports and bracing.
  2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
  3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
  4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
- I. Fastening Hardware:
  1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
  2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.



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- J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
- K. Corrosive Environments:
  - 1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
    - a. Laboratory exhaust-air streams.
    - b. Process exhaust-air streams.
  - 2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
  - 3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

### **3.5 CONTROLLER INSTALLATION**

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply and to UPS units where indicated.
- C. Install controller with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
  - 1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
  - 2. Install controllers in a protected location that is easily accessible by operators.
  - 3. Top of controller shall be within 72 inches of finished floor.
- F. Installation of Programmable Application Controllers:
  - 1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
  - 2. Install controllers in a protected location that is easily accessible by operators.
  - 3. Top of controller shall be within 72 inches of finished floor.
- G. Application-Specific Controllers:

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1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

### **3.6 ENCLOSURES INSTALLATION**

- A. Install the following items in enclosures, to comply with indicated requirements:
  1. Gateways.
  2. Routers.
  3. Controllers.
  4. Electrical power devices.
  5. UPS units.
  6. Relays.
  7. Accessories.
  8. Instruments.
  9. Actuators
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
  1. For NEMA 250, Type 1 Enclosures: Use painted steel strut and hardware.
  2. For NEMA 250, Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
  3. Install plastic caps on exposed cut edges of strut.
- C. Align top or bottom of adjacent enclosures of like size.
- D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.
- E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

### **3.7 ELECTRIC POWER CONNECTIONS**

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
- C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

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- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

### **3.8 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install self-adhesive labels with unique identification on face for each of the following:
  - 1. Gateway.
  - 2. Router.
  - 3. Protocol analyzer.
  - 4. DDC controller.
  - 5. Enclosure.
  - 6. Electrical power device.
  - 7. UPS unit.
  - 8. Accessory.
- C. Install unique instrument identification on face of each instrument connected to a DDC controller.
- D. Install unique identification on face of each control damper and valve actuator connected to a DDC controller.
- E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
- F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
- G. Warning Labels and Signs:
  - 1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
  - 2. Shall be located in highly visible location near power service entry points.

### **3.9 NETWORK INSTALLATION**

- A. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:
  - 1. Network controllers.
- B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
  - 1. Gateways.
  - 2. Gateways and network controllers or programmable application controllers.
  - 3. Routers.

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4. Routers and network controllers or programmable application controllers.
  5. Network controllers and programmable application controllers.
  6. Programmable application controllers.
  7. Programmable application controllers and application-specific controllers.
  8. Application-specific controllers.
- C. Install cable in continuous raceway.
1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

### **3.10 NETWORK NAMING AND NUMBERING**

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.
- B. ASHRAE 135 Networks:
1. MAC Address:
    - a. Every network device shall have an assigned and documented MAC address unique to its network.
    - b. Ethernet Networks: Document MAC address assigned at its creation.
    - c. ARCNET or MS/TP networks: Assign from 00 to 64.
  2. Network Numbering:
    - a. Assign unique numbers to each new network.
    - b. Provide ability for changing network number through device switches or operator interface.
    - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
  3. Device Object Identifier Property Number:
    - a. Assign unique device object identifier property numbers or device instances for each device network.
    - b. Provide for future modification of device instance number by device switches or operator interface.
    - c. LAN shall support up to 4,194,302 unique devices.
  4. Device Object Name Property Text:
    - a. Device object name property field shall support 32 minimum printable characters.
    - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
      - 1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
      - 2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

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5. Object Name Property Text for Other Than Device Objects:
  - a. Object name property field shall support 32 minimum printable characters.
  - b. Assign object name properties with plain-English names descriptive of application.
    - 1) Example 1: "Zone 1 Temperature."
    - 2) Example 2 "Fan Start and Stop."
6. Object Identifier Property Number for Other Than Device Objects:
  - a. Assign object identifier property numbers according to Drawings or tables indicated.
  - b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

### **3.11 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION**

- A. Comply with NECA 1.
- B. Wire and Cable Installation:
  1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
  2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
  3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
  4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
    - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
  5. Terminate wiring in a junction box.
    - a. Clamp cable over jacket in junction box.
    - b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
  6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
  7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
  8. Use shielded cable to transmitters.
  9. Use shielded cable to temperature sensors.
  10. Perform continuity and meager testing on wire and cable after installation.

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C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

**3.12 FIELD QUALITY CONTROL**

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

**3.13 DDC SYSTEM I/O CHECKOUT PROCEDURES**

- A. Check installed products before continuity tests, leak tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

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- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
- E. For pneumatic products, verify that air supply for each product is properly installed.
- F. Control Damper Checkout:
  - 1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
  - 2. Verify that control dampers are installed correctly for flow direction.
  - 3. Verify that proper blade alignment, either parallel or opposed, has been provided.
  - 4. Verify that damper frame attachment is properly secured and sealed.
  - 5. Verify that damper actuator and linkage attachment is secure.
  - 6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
  - 7. Verify that damper blade travel is unobstructed.
- G. Control Valve Checkout:
  - 1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
  - 2. Verify that control valves are installed correctly for flow direction.
  - 3. Verify that valve body attachment is properly secured and sealed.
  - 4. Verify that valve actuator and linkage attachment is secure.
  - 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
  - 6. Verify that valve ball, disc or plug travel is unobstructed.
  - 7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.
- H. Instrument Checkout:
  - 1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
  - 2. Verify that attachment is properly secured and sealed.
  - 3. Verify that conduit connections are properly secured and sealed.
  - 4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
  - 5. Inspect instrument tag against approved submittal.
  - 6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
  - 7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
  - 8. For temperature instruments:
    - a. Verify sensing element type and proper material.
    - b. Verify length and insertion.

**3.14 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:**

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

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- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
- F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
- G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
- I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- J. Analog Signals:
  - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
  - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
  - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- K. Digital Signals:
  - 1. Check digital signals using a jumper wire.
  - 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- L. Control Dampers:
  - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
  - 2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
  - 3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
  - 4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- M. Control Valves:
  - 1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.



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2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
  3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
  4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
- O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- P. Switches: Calibrate switches to make or break contact at set points indicated.
- Q. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
  2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

### **3.15 DDC SYSTEM CONTROLLER CHECKOUT**

- A. Verify power supply.
1. Verify voltage, phase and hertz.
  2. Verify that protection from power surges is installed and functioning.
  3. Verify that ground fault protection is installed.
  4. If applicable, verify if connected to UPS unit.
  5. If applicable, verify if connected to a backup power source.
  6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.
- B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.

### **3.16 DDC CONTROLLER I/O CONTROL LOOP TESTS**

- A. Testing:
1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
  2. Test every I/O point throughout its full operating range.
  3. Test every control loop to verify operation is stable and accurate.
  4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.

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5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
  - a. Upper quarter of range.
  - b. Lower quarter of range.
  - c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

**3.17 DDC SYSTEM VALIDATION TESTS**

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After approval of Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed test checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
  1. Detailed explanation for any items that are not completed or verified.
  2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
  3. HVAC equipment motors operate below full-load amperage ratings.
  4. Required DDC system components, wiring, and accessories are installed.
  5. Installed DDC system architecture matches approved Drawings.
  6. Control electric power circuits operate at proper voltage and are free from faults.
  7. Required surge protection is installed.
  8. DDC system network communications function properly, including uploading and downloading programming changes.
  9. Using BACnet protocol analyzer, verify that communications are error free.
  10. Each controller's programming is backed up.
  11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
  12. All I/O points are programmed into controllers.
  13. Testing, adjusting and balancing work affecting controls is complete.
  14. Dampers and actuators zero and span adjustments are set properly.
  15. Each control damper and actuator goes to failed position on loss of power.
  16. Valves and actuators zero and span adjustments are set properly.
  17. Each control valve and actuator goes to failed position on loss of power.
  18. Meter, sensor and transmitter readings are accurate and calibrated.
  19. Control loops are tuned for smooth and stable operation.
  20. View trend data where applicable.

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21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
  - a. Verify analog I/O points at operating value.
  - b. Make adjustments to out-of-tolerance I/O points.
    - 1) Identify I/O points for future reference.
    - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
    - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
  - a. Re-check I/O points that required corrections during initial test.
  - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. After 24 Hours of Second Validation Test:
  - a. Re-check I/O points that required corrections during second test.
  - b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.

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7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

**3.18 FINAL REVIEW**

- A. Submit written request to Architect when DDC system is ready for final review. Written request shall state the following:
  1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
  2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
  3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
  4. DDC system is complete and ready for final review.
- B. Review by Architect shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
- E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.
- F. A part of DDC system final review shall include a demonstration to parties participating in final review.
  1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
  2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
  3. Demonstration shall include, but not be limited to, the following:
    - a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    - b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points

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- shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
- c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
  - d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
  - e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
  - f. Trends, summaries, logs and reports set-up for Project.
  - g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
  - h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
  - i. Software's ability to edit control programs off-line.
  - j. Data entry to show Project-specific customizing capability including parameter changes.
  - k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
  - l. Execution of digital and analog commands in graphic mode.
  - m. Spreadsheet and curve plot software and its integration with database.
  - n. Online user guide and help functions.
  - o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
  - p. System speed of response compared to requirements indicated.
  - q. For Each Network and Programmable Application Controller:
    - 1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
    - 2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
    - 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
    - 4) Electric Power: Ability to disconnect any controller safely from its power source.
    - 5) Wiring Labels: Match control drawings.
    - 6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
    - 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.
  - r. For Each Operator Workstation:
    - 1) I/O points lists agree with naming conventions.
    - 2) Graphics are complete.
    - 3) UPS unit, if applicable, operates.

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- s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.
  - 1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
  - 2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
  - 3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.
  - 4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
  - 5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
  - 6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
  - 7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
  - 8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
  - 9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
  - 10) Device and Network Management:
    - a) Display of network device status.
    - b) Display of BACnet Object Information.
    - c) Silencing devices transmitting erroneous data.
    - d) Time synchronization.
    - e) Remote device re-initialization.
    - f) Backup and restore network device programming and master database(s).
    - g) Configuration management of routers.

### 3.19 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

### **3.20 SOFTWARE SERVICE AGREEMENT**

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two year(s).
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
  - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

### **3.21 DEMONSTRATION**

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:
  - 1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
  - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
  - 3. Minimum Training Requirements:
    - a. Provide not less than 2 hours of on-site training at completion of Phase 1 and an additional 2 hours of on-site training at completion of Phase 2.
    - b. In addition to on-site training, provide at least two days (16 hrs) of structured training to occur 6 months after project completion.
    - c. Stagger training over multiple (2 hr maximum) training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
    - d. Total days of training shall be broken into approximately eight (8) separate training classes.
    - e. Training classes may be conducted on-site if approved by owner, otherwise it is expected that off-site training accommodations will be provided.
- C. Training Schedule:
  - 1. Schedule training with Owner 20 business days before expected Substantial Completion.
  - 2. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
  - 3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 15-minute break between sessions. Morning and afternoon sessions shall be separated by 30-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
  - 4. Provide staggered training schedule as requested by Owner.

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D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to two attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

1. High school and technical school education and degree.
2. Basic user knowledge of computers and office applications.
3. Intermediate knowledge of HVAC systems.
4. Intermediate knowledge of DDC systems.
5. Intermediate knowledge of DDC system and products installed.

G. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:



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1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate daily operators:
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

J. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide a workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.

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10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
  - a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
  - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
  - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
  - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
  - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
  - f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
  - g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

**END OF SECTION 23 0923**

## **SECTION 23 0923.11**

### **CONTROL VALVES**

#### **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 control valves and actuators for DDC systems.
- B. Related Requirements:
  - 1. Section 230923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
  - 2. Section 230993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.11.

##### **1.3 DEFINITIONS**

- A. Cv: Design valve coefficient.
- B. DDC: Direct-digital control.
- C. NBR: Nitrile butadiene rubber.
- D. PTFE: Polytetrafluoroethylene
- E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

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- power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation, operation, and maintenance instructions, including factors affecting performance.
- B. Shop Drawings:
- 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4.

## **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.
- E. Environmental Conditions:
  - 1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
    - a. Hazardous Locations: Explosion-proof rating for condition.
- F. Determine control valve sizes and flow coefficients by ISA 75.01.01.
- G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

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H. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:
  - a. Chilled Water: 150 psig @ 40 deg F
  - b. Heating Hot Water: 150 psig @ 225 deg F
2. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
3. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
4. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
5. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
6. Modulating butterfly valves shall have linear or equal percentage flow-throttling characteristics.
7. Fail positions unless otherwise indicated:
  - a. Chilled Water: Close.
  - b. Heating Hot Water: Open.
8. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.
9. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
10. Selection shall consider viscosity, flashing, and cavitation corrections.
11. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
12. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
13. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.
14. Modulating valve sizes for steam service shall provide a pressure drop at design flow equal to lesser of the following:
  - a. 50 percent of the valve inlet pressure.
  - b. 50 percent of the absolute steam pressure at the valve inlet.
15. Two-position control valves shall be line size unless otherwise indicated.
16. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.
17. In steam systems, use ball- or globe-style control valves regardless of size.
18. Pneumatic, two-position control valves shall provide a smooth opening and closing characteristic slow enough to avoid water hammer. Valves with pneumatic actuators shall have an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from zero to 10 seconds. Opening and closing times shall be independently adjustable.

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19. Control valve, pneumatic-control signal shall not exceed 200 feet. For longer distances, provide an electric/electronic control signal to the valve and an electric solenoid valve or electro-pneumatic transducer at the valve to convert the control signal to pneumatic.

## 2.2 BALL-STYLE CONTROL VALVES

### A. Ball Valves with Full Ball and Characterized V-Notch:

1. Performance:
  - a. Process Temperature Rating: Minus 20 to plus 500 deg F.
  - b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 for larger than NPS 2.
  - c. Leakage: FCI 70-2, Class VI, bi-directional.
  - d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
  - e. Rotation: Zero to 90 degrees.
  - f. Equal percentage flow characteristic.
  - g. Full port.
2. Face-to-Face Dimension: ASME B16.10 long pattern.
3. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
4. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
5. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
6. Replaceable seat, ball, and shaft packing.
7. Body: Carbon steel.
8. Ball and Shaft: Brass or Stainless steel.
9. Ball Seat: RPTFE.
10. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.
  - a. Primary Seal: Combination of thrust washer and thrust washer protector.
  - b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
11. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.
  - a. Primary Seal: Combination of thrust washer and thrust washer protector.
  - b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
12. Label each valve with following:
  - a. Manufacturer's name, model number, and serial number.
  - b. Body size.
  - c. Flow directional arrow.

### B. Ball Valves with Segmented Ball, Three-Way Pattern:

1. Arrangement: Two single-port valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:

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- a. Process Temperature Rating: Minus 20 to plus 450 deg F.
  - b. ASME B16.34, Class 150.
  - c. Leakage: FCI 70-2, Class IV.
  - d. Rangeability: 300 to 1.
  - e. Rotation: Zero to 90 degrees.
  - f. Equal percentage flow characteristic.
3. Face-to-Face Dimensions: ASME B16.10.
4. Valves NPS 3 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon steel.
6. Ball and Shaft: Brass or Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.
8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:
  - a. Manufacturer's name, model number, and serial number.
  - b. Body size.
  - c. Flow directional arrow.

## 2.3 BUTTERFLY-STYLE CONTROL VALVES

### A. Commercial-Grade, Two-Way Butterfly Valves:

1. Performance:
  - a. Bi-directional bubble tight shutoff at 250 psig.
  - b. Comply with MSS SP-67 or MSS SP-68.
  - c. Rotation: Zero to 90 degrees.
  - d. Linear or modified equal percentage flow characteristic.
2. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:
  - a. Manufacturer's name, model number, and serial number.
  - b. Body size.
  - c. Body and trim materials.
  - d. Flow arrow.

### B. Commercial-Grade, Three-Way Butterfly Valves:

1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:

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- a. Bi-directional bubble tight shutoff at 250 psig.
  - b. Comply with MSS SP-67 or MSS SP-68.
  - c. Rotation: Zero to 90 degrees.
  - d. Linear or modified equal percentage flow characteristic.
3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
  - a. Manufacturer's name, model number, and serial number.
  - b. Body size.
  - c. Body and trim materials.
  - d. Flow arrow.

## 2.4 GLOBE-STYLE CONTROL VALVES

### A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:
  - a. Manufacturer's name, model number, and serial number.
  - b. Body and trim size.
  - c. Arrow indicating direction of flow.

### B. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Globe Style: Single port.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F.
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.



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- C. Three-Way Globe Valves NPS 2-1/2 to NPS 6:
  - 1. Globe Style: Mix flow pattern.
  - 2. Body: Cast iron complying with ASME B61.1, Class 125.
  - 3. End Connections: Flanged suitable for mating to ASME B16.5, Class 150 flanges.
  - 4. Bonnet: Bolted.
  - 5. Packing: PTFE cone-ring.
  - 6. Plug: Top or bottom guided.
  - 7. Plug, Seat, and Stem: Brass or stainless steel.
  - 8. Process Temperature Rating: 35 to 281 deg F.
  - 9. Leakage: 0.1 percent of maximum flow.
  - 10. Rangeability: Varies with valve size between 6 and 10 to 1.
  - 11. Modified linear flow characteristic.
  - 12. Flow Characteristic: Equal percentage.

## **2.5 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS**

- A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
- B. Position indicator and graduated scale on each actuator.
- C. Type: Motor operated, with or without gears, electric and electronic.
- D. Voltage: Voltage selection delegated to professional designing control system.
- E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- F. Function properly within a range of 85 to 120 percent of nameplate voltage.
- G. Construction:
  - 1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
  - 2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
  - 3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- H. Field Adjustment:
  - 1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
  - 2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
- I. Two-Position Actuators: Single direction, spring return or reversing type.

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J. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
  - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
  - b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
  - c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
  - d. Programmable Multi-Function:
    - 1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
    - 2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
    - 3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

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1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:

1. Operate valve from fully closed to fully open within 75 seconds.
2. Operate valve from fully open to fully closed within 75 seconds.
3. Move valve to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.

R. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 CONTROL VALVE APPLICATIONS**

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. Hydronic System, Chilled & Heating Hot Water, Two-Way Applications Controlled by Temperature: Ball valves with single port and characterized disk Ball valves with single port and segmented ball Ball valves with full ball and characterized V-notch Pressure-independent ball valves Butterfly-style valves, commercial-grade, two-way valves Globe-style, two-way valves.
3. Hydronic System, Chilled & Heating Hot Water, Three Way, Controlled by Temperature: Ball valves with two ports and characterized disk Ball valves with segmented ball, three-way pattern Butterfly-style valves, commercial-grade, three-way valves Globe-style, three-way valves.

### **3.3 INSTALLATION, GENERAL**

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 50lb force.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.
- F. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
  2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

### **3.4 ELECTRIC POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### **3.5 CONTROL VALVES**

- A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.
- D. Valve Orientation:
  - 1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
  - 2. Install valves in a position to allow full stem movement.
  - 3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.
- E. Clearance:
  - 1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
  - 2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.
- F. Threaded Valves:
  - 1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
  - 2. Align threads at point of assembly.
  - 3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
  - 4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

G. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

**3.6 CONNECTIONS**

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

**3.7 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with valve identification on valve.

**3.8 CLEANING**

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

**3.9 CHECKOUT PROCEDURES**

- A. Control Valve Checkout:
1. Check installed products before continuity tests, leak tests, and calibration.
  2. Check valves for proper location and accessibility.
  3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
  4. For pneumatic products, verify air supply for each product is properly installed.
  5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
  6. Verify that control valves are installed correctly for flow direction.
  7. Verify that valve body attachment is properly secured and sealed.
  8. Verify that valve actuator and linkage attachment are secure.
  9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
  10. Verify that valve ball, disc, and plug travel are unobstructed.

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11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

**3.10 ADJUSTMENT, CALIBRATION, AND TESTING**

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

**END OF SECTION 23 0923.11**





**SECTION 23 0923.12**

**CONTROL DAMPERS**

**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 the following types of control dampers and actuators for DDC systems:
  - 1. Rectangular control dampers.
  - 2. Round control dampers.
  - 3. General control-damper actuator requirements.
  - 4. Electric and electronic actuators.
- B. Related Requirements:
  - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
  - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.12.

**1.3 DEFINITIONS**

- A. DDC: Direct-digital control.
- B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

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- power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation instructions, including factors affecting performance.
- B. Shop Drawings:
- 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Include diagrams for air and process signal tubing.
  - 5. Include diagrams for pneumatic signal and main air tubing.
- C. Delegated-Design Submittal:
- 1. Schedule and design calculations for control dampers and actuators, including the following.
    - a. Flow at project design and minimum flow conditions.
    - b. Face velocity at project design and minimum airflow conditions.
    - c. Pressure drop across damper at project design and minimum airflow conditions.
    - d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
    - e. Maximum close-off pressure.
    - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
    - g. Torque required at worst case condition for sizing actuator.
    - h. Actuator selection indicating torque provided.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation 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. Product installation location shown in relationship to room, duct, and equipment.
  - 2. Size and location of wall access panels for control dampers and actuators installed behind walls.
  - 3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.
- E. Environmental Conditions:
  - 1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
- F. Selection Criteria:
  - 1. Control dampers shall be suitable for operation at following conditions:
    - a. Supply Air: 6" w.c. at (-) 75 F to (+) 275 F
    - b. Return Air: 6" w.c. at (-) 75 F to (+) 275 F
    - c. Outdoor Air: 6" w.c. at (-) 75 F to (+) 275 F
    - d. Exhaust Air: 6" w.c. at (-) 75 F to (+) 275 F
  - 2. Fail positions unless otherwise indicated:
    - a. Supply Air: Open.
    - b. Return Air: Open.
    - c. Outdoor Air: Close.
    - d. Exhaust Air: Close.
  - 3. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
  - 4. Select modulating dampers for a pressure drop of 5 percent of fan total static pressure unless otherwise indicated.
  - 5. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

## 2.2 RECTANGULAR CONTROL DAMPERS

### A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

### B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:
  - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
  - b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
  - c. Velocity: Up to 6000 fpm.
  - d. Temperature: Minus 40 to plus 185 deg F.
  - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
  - f. Damper shall have AMCA seal for both air leakage and air performance.
2. Construction:
  - a. Frame:
    - 1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
    - 2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
    - 3) Width not less than 5 inches.
  - b. Blades:
    - 1) Hollow, airfoil, extruded aluminum.
    - 2) Parallel or opposed blade configuration as required by application.
    - 3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
    - 4) Width not to exceed 6 inches.
    - 5) Length as required by close-off pressure, not to exceed 48 inches.
  - c. Seals:
    - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
    - 2) Jambs: Stainless steel, compression type.

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- d. Axles: 0.5-inch-diameter plated or stainless steel, mechanically attached to blades.
- e. Bearings:
  - 1) Molded synthetic or stainless-steel sleeve mounted in frame.
  - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
  - 1) Concealed in frame.
  - 2) Constructed of aluminum and plated or stainless steel.
  - 3) Hardware: Stainless steel.
- g. Transition:
  - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
  - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
  - 3) Damper size and sleeve shall be connection size plus 2 inches.
  - 4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
  - 5) Sleeve material shall match adjacent duct.
- h. Additional Corrosion Protection for Corrosive Environments:
  - 1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
  - 2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

## 2.3 ROUND CONTROL DAMPERS

### A. Round Dampers, Sleeve Type:

- 1. Performance:
  - a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
  - b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
  - c. Velocity: Up to 4000 fpm.
  - d. Temperature: Minus 25 to plus 200 deg F.
  - e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.
- 2. Construction:
  - a. Frame:
    - 1) Material: Galvanized or stainless steel, 0.04 in thick.

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- 2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
    - 3) Sleeve-type connection for mating to adjacent ductwork.
    - 4) Size Range: 4 to 24 inches.
    - 5) Length not less than 7 inches.
    - 6) Provide 2-inch sheet metal stand-off for mounting actuator.
  - b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized or stainless steel.
  - c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
  - d. Axle: 0.5-inch-diameter plated or stainless steel, mechanically attached to blade.
  - e. Bearings: Stainless-steel sleeve pressed into frame.
- B. Round Dampers, Flanged Type:
- 1. Performance:
    - a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
    - b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
    - c. Velocity: Up to 4000 fpm.
    - d. Temperature: Minus 25 to plus 250 deg F.
    - e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.
  - 2. Construction:
    - a. Frame:
      - 1) Size Range: 4 to 60 inches.
      - 2) Material: Galvanized or stainless steel.
        - a) Sizes through 24 Inches in Diameter: 0.15 inch thick.
        - b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.
        - c) Larger Sizes: 0.31 inch thick.
      - 3) Flanges:
        - a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.
        - b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.
      - 4) Length (Flange Face to Face): Not less than 8 inches.
      - 5) Provide 3-inch sheet metal stand-off for mounting actuator.
    - b. Blade: Reinforced circular flat blade constructed of galvanized or stainless steel.
      - 1) Sizes through 24 Inches: 0.15 inch thick.

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- 2) Sizes 26 through 48 Inches: 0.19 inch thick.
  - 3) Larger Sizes: 0.25 inch thick.
- c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized- or stainless- steel bar.
- d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.
- e. Axle: Plated or stainless steel, mechanically attached to blade.
  - 1) Sizes through 14 Inches: 0.5 inch in diameter.
  - 2) Sizes 16 through 42 Inches: 0.75 inch in diameter.
  - 3) Larger Sizes: 1 inch in diameter.
- f. Bearings: Stainless-steel sleeve pressed into frame.

## 2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
- C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
- D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
- E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- G. Provide mounting hardware and linkages for connecting actuator to damper.
- H. Select actuators to fail in desired position in the event of a power failure.
- I. Actuator Fail Positions: As indicated below:
  - 1. Exhaust Air: Close.
  - 2. Outdoor Air: Close.
  - 3. Supply Air: Open.
  - 4. Return Air: Open.

## **2.5 ELECTRIC AND ELECTRONIC ACTUATORS**

- A. Type: Motor operated, with or without gears, electric and electronic.
- B. Voltage:
  - 1. Voltage selection is delegated to professional designing control system.
  - 2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
  - 3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
- C. Construction:
  - 1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
  - 2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
  - 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- D. Field Adjustment:
  - 1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
  - 2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- E. Two-Position Actuators: Single direction, spring return or reversing type.
- F. Modulating Actuators:
  - 1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
  - 2. Control Input Signal:
    - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
    - b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
    - c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
    - d. Programmable Multi-Function:
      - 1) Control input, position feedback, and running time shall be factory or field programmable.



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- 2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
- 3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

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M. Stroke Time:

1. Operate damper from fully closed to fully open within 90 seconds.
2. Operate damper from fully open to fully closed within 90 seconds.
3. Move damper to failed position within 30 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 CONTROL-DAMPER APPLICATIONS**

- A. Control Dampers:
- B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
  1. Rectangular Exhaust Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
  2. Round Exhaust Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
  3. Rectangular Outdoor Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.

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4. Round Outdoor Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
5. Rectangular Return Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
6. Round Return Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
7. Rectangular Supply Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.
8. Round Supply Air Duct Applications with Pressure Rating at 6.0" w.c. and Velocities to 6000 FPM: Rectangular dampers with aluminum airfoil blades Round dampers, sleeve type Round dampers, flange type.

### **3.3 INSTALLATION, GENERAL**

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 50 lb force.
- C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Seal penetrations made in fire-rated and acoustically rated assemblies.
- E. Fastening Hardware:
  1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
  2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

### **3.4 ELECTRIC POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

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- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### **3.5 CONTROL DAMPERS**

- A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
- B. Clearance:
  - 1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
  - 2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.
- C. Service Access:
  - 1. Dampers and actuators shall be accessible for visual inspection and service.
  - 2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."
- D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
- E. Attach actuator(s) to damper drive shaft.
- F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

### **3.6 CONNECTIONS**

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

### **3.7 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

- B. Install engraved phenolic nameplate with damper identification on damper.

### **3.8 CHECKOUT PROCEDURES**

- A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

### **3.9 ADJUSTMENT, CALIBRATION, AND TESTING:**

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

**END OF SECTION 23 0923.12**



**SECTION 23 0923.14**

**FLOW INSTRUMENTS**

**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. Airflow sensors.
  - 2. Airflow switches.
  - 3. Airflow transmitters.
  - 4. Liquid flow meters.
  - 5. Liquid flow sensors.
  - 6. Liquid flow switches.
  - 7. Liquid flow transmitters.
- B. Related Requirements:
  - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
  - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.14.

**1.3 DEFINITIONS**

- A. Ethernet: Local area network based on IEEE 802.3 standards.
- B. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- C. PEEK: polyetheretherketone.
- D. PTFE: Polytetrafluoroethylene.

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- E. PPS: Polyphenylene sulfide.
- F. RS-485: A TIA standard for multipoint communications using two twisted pairs.
- G. RTD: Resistance temperature detector.
- H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation instructions, including factors affecting performance.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Include diagrams for air and process signal tubing.
  - 5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

#### **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.



## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Select and size products to achieve specified performance requirements.
- B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### **2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS**

- A. Air sensors and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
- B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

### **2.3 AIRFLOW SENSORS:**

- A. Performance Requirements:
  - 1. Adjustable for changes in system operational parameters.
  - 2. Airflow Sensor and Transmitter Range: Extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions.
  - 3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
    - a. Product certificates are required.
- B. Pitot-Tube Airflow Sensor Station:
  - 1. Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.
    - a. Stations 4 sq. ft. and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. of station area.
    - b. Stations Larger than 4 sq. ft.: One total-pressure sensor and one static-pressure sensor for every 36 sq. in. of station area.
  - 2. Casing: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.

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- a. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.
  - b. Casing Depth: At least 8 inches.
  - c. Casing Flanges: Outward flange, minimum flange face 1.5 inches.
  - d. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.
3. Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.
  - a. Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless-steel casings.
4. Construct pressure sensor array from drawn copper or stainless-steel tubing. Use stainless steel for units with stainless-steel casings. Copper tubing shall comply with ASTM B 75 and ASTM B 280. Minimum tube wall thickness shall be 0.030 inch. Include internal piping and external pressure transmitter ports.
5. Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.
6. Performance:
  - a. Pressure Loss: 0.015-inch wg at 1000 fpm, or 0.085-inch wg at 2000 fpm.
  - b. Accuracy: Within 2 percent of actual airflow.
  - c. Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.
  - d. Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.
- C. Pitot-Tube Fan Inlet Airflow Traverse Sensor:
  1. Traverse manifold designed for mounting in fan inlets.
  2. Contain multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the manifold nor be adversely affected by particle contamination present in airstream.
  3. Manifold (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.
  4. Sensors shall be capable of producing steady, non-pulsating signals of standard total- and static-pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a turndown range of 6 to 1.
  5. Manifold Materials: Copper or anodized aluminum or Type 316 stainless steel.
  6. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter copper and aluminum manifolds shall be the following:
    - a. For Fan Inlets Smaller than 20 Inches: 0.375 inch.
    - b. For Fan Inlets 20 Inches and Larger: 0.75 inch.
  7. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter stainless-steel manifolds shall be the following:

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- a. For Fan Inlets Smaller than 20 Inches: 0.375 inch.
  - b. For Fan Inlets 20 through 48 Inches: 0.75 inch.
  - c. For Fan Inlets Larger than 48 Inches: 1.0 inch.
- D. Piezometer Ring Fan Inlet Airflow Sensor:
1. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.
  2. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
  3. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
  4. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
  5. Sensor shall be non-intrusive and not impact fan performance.
  6. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.
- E. Thermal Airflow Station:
1. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
  2. Description: Airflow station shall consist of one or more sensor probes mounted in a casing, and a remotely mounted microprocessor-based transmitter.
  3. Performance:
    - a. Capable of independently processing up to 16 independently wired sensor assemblies.
    - b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
    - c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
    - d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
    - e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
    - f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
    - g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.
      - 1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
    - h. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
    - i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
    - j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
    - k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.

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- l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
  - m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
  - n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.
- 4. Sensor Assemblies:
  - a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
  - b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
  - c. Thermistor leads shall be protected and not exposed to the environment.
  - d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
  - e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
  - f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
  - g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.
- 5. Casing:
  - a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.
  - b. Material: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
  - c. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.
  - d. Casing Depth: At least 8 inches.
  - e. Include casing inlet and discharge connections with a minimum 1.5-inch face flange.
- 6. Transmitter:
  - a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
  - b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
    - 1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
      - a) Integral protection from transients and power surges.
      - b) Circuitry to ensure reset after power disruption, transients, and brownouts.

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- c) Integral transformer to convert field power source to operating voltage required by instrument.
- c. Remote Signal Interface:
  - 1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, field selectable, zero- to 10-V dc or 4 to 20 mA.
  - 2) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.
  - 3) 10 Base-T Ethernet: BACnet Ethernet, BACnet-IP, Modbus-TCP, and TCP/IP.
  - 4) LonWorks free topology.

## 2.4 AIRFLOW SWITCHES

### A. Polymer Film Sail Switch:

- 1. Performance:
  - a. Suitable for applications operating at velocities up to 400 fpm.
  - b. Suitable for mounting with air direction in horizontal, vertical up or down.
  - c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - d. Voltage: 24-, 120-, 240-V ac.
  - e. Normally Open Full Load Current: 2 A at 120-V ac.
  - f. Normally Closed Full Load Current: 1 A at 120-V ac.
  - g. Normally open switch actuates at 250 fpm and opens at 75 fpm.
  - h. Normally closed switch actuates at 75 fpm and closes at 250 fpm.
  - i. Maximum Process Temperature: 170 deg F.
  - j. Maximum Ambient Temperature: 125 deg F.
- 2. Construction:
  - a. Polyester film sail encasing a wire frame.
  - b. Sail actuates a SPDT snap switch.
  - c. Enclosure Material: Zinc-plated steel.
  - d. Enclosure with removable cover.
  - e. NEMA 250, Type 1 enclosure.
  - f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
  - g. Electrical Connections: Screw terminals.
  - h. Conduit Connections: 1/2-inch trade size conduit knock outs on top and bottom.

### B. Stainless-Steel Single Vane Switch:

- 1. Description:
  - a. Velocities up to 2000 fpm.
  - b. Suitable for mounting with air direction in horizontal.
- 2. Performance:
  - a. Voltage: 125-, 240-, and 480-V ac.

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- b. Full Load Current: 9.8 A at 125-V ac.
  - c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
  - d. Maximum Process Temperature: 180 deg F.
  - e. Maximum Ambient Temperature: 125 deg F.
- 3. Construction:
  - a. Stainless-steel vane.
  - b. Vane actuates a SPDT snap switch.
  - c. Enclosure Material: Die-cast metal.
  - d. Enclosure with removable cover.
  - e. NEMA 250, Type 1 enclosure.
  - f. Screw set-point adjustment.
  - g. Electrical Connections: Screw terminals.
  - h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

## 2.5 AIRFLOW TRANSMITTERS

- A. Airflow Transmitter with 0.10 Percent Accuracy and Auto-Zero Feature:
  - 1. Transmitter shall receive total- and static-pressure signals from a primary element, amplify signals, extract the square root, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
  - 2. NEMA 250, Type 1 enclosure.
  - 3. Construct assembly so that shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
  - 4. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
  - 5. Performance:
    - a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
    - c. Accuracy: Within 0.10 percent of natural span.
    - d. Repeatability: Within 0.15 percent of calibrated span.
    - e. Linearity: Within 0.2 percent of calibrated span.
    - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
  - 6. Integral digital LED or digital display for continuous indication of airflow.
- B. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:
  - 1. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
  - 2. NEMA 250, Type 1 enclosure.
  - 3. Construct assembly so shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
  - 4. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.

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5. Performance:
    - a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
    - c. Accuracy: Within 0.25 percent of natural span.
    - d. Repeatability: Within 0.15 percent of calibrated span.
    - e. Linearity: Within 0.2 percent of calibrated span.
    - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
  6. Integral digital display for continuous indication of airflow.
- C. Pressure Differential Transmitters for Airflow Measurement:
1. Performance:
    - a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    - b. Accuracy: Within 0.5 percent of the full-scale range.
    - c. Hysteresis: Within 0.10 percent of full scale.
    - d. Repeatability: Within 0.05 percent of full scale.
    - e. Stability: Within one percent of span per year.
    - f. Overpressure: 10 psig.
    - g. Temperature Limits: Zero to 150 deg F.
    - h. Compensate Temperature Limits: 40 to 150 deg F.
    - i. Thermal Effects: 0.033 percent of full scale per degree F.
    - j. Shock and vibration shall not harm the transmitter.
  2. Output Signals:
    - a. Analog Current Signal:
      - 1) Two-wire, 4- to 20-mA dc current source.
      - 2) Signal capable of operating into 800-ohm load.
    - b. Analog Voltage Signal:
      - 1) Three wire, zero to 10 V.
      - 2) Minimum Load Resistance: 1000 ohms.
  3. Display: Four-digit digital with minimum 0.4-inch-high numeric characters.
  4. Operator Interface:
    - a. Zero and span adjustments located behind cover.
  5. Construction:
    - a. Plastic casing with removable plastic cover.
    - b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
    - c. Screw terminal block for wire connections.
    - d. Vertical plane mounting.

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- e. NEMA 250, Type 4.
  - f. Mounting Bracket: Appropriate for installation.
- D. Pressure Differential Indicating Transmitter, Switch, and Controller for Airflow Measurement:
- 1. Description:
    - a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
    - b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
    - c. Select instrument range based on application.
  - 2. Performance:
    - a. Accuracy including hysteresis and repeatability:
      - 1) Ranges Less than 5-Inch wg: Within 1 percent.
      - 2) Other Ranges: Within 0.5 percent at 77 deg F.
    - b. Stability: Within 1 percent per year.
    - c. Response Time: 250 ms.
    - d. Overpressure:
      - 1) Ranges Less than 50-Inch wg: 5 psi
      - 2) Range of 100-Inch wg: 9 psi.
    - e. Temperature Limits: 32 to 140 deg F.
    - f. Thermal Effects: 0.020 percent per deg F.
    - g. Warm-up Period: One hour.
  - 3. Controller: Programming through menu keys to access five menus.
    - a. Security level.
    - b. Pressure, velocity, or flow application.
    - c. Engineering units.
    - d. K-factor for use with flow application.
    - e. Set-point control only; set-point and alarm operation; alarm operation as high, low, or high/low with manual; or automatic reset and delay.
    - f. View high and low readings.
    - g. Digital dampening for smoothing erratic applications.
    - h. Scaling of analog output to fit range and field calibration.
  - 4. Display:
    - a. Four-digit digital, with minimum 0.4-inch-high alphanumeric characters.
    - b. Four LED indicators; two LEDs for set point and two LEDs for alarm status.
  - 5. Operator Interface:
    - a. Set-point adjustment through keypad on face of instrument.
    - b. Zero and span adjustments accessible through menu.



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- c. Programming through keypad.
- 6. Output Analog Signal: Two-wire, 4- to 20-mA dc current source; capable of operating into a 900-ohm load.
- 7. Output Digital Signal: Two, SPDT relays; each rated for 1 A at 30-V ac or 30-V dc.
- 8. Construction:
  - a. Die-cast aluminum casing and bezel.
  - b. Connections on side and back.
  - c. Vertical plane mounting.
  - d. NEMA 250, Type 1 rating.
  - e. Nominal 4-inch-diameter face.
  - f. Mounting Bracket: Appropriate for installation.

## 2.6 LIQUID FLOW METERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Onicon, Inc.
  - 2. Flexim, Inc.
- B. General Requirements for Liquid Flow Meters:
  - 1. Adjustable for changes in system operational parameters.
  - 2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 10 percent above Project design flow and 10 percent below Project minimum flow to signal abnormal flow conditions.
  - 3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
  - 4. Product certificates are required.
- C. Insertion Turbine Flow Meter:
  - 1. Description:
    - a. Operating pressure of 300 psig with a temperature of 200 deg F.
    - b. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
    - c. Pressure drop not to exceed 1 psig at 20-fps flow velocity in a NPS 2 pipe and decreasing in large pipe with lower velocity.
    - d. Sensor Accuracy:
      - 1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps.
      - 2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps.
      - 3) Within 0.5 percent of actual reading at the calibrated velocity.
    - e. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

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2. Sensor:

- a. For Pipe Sizes NPS 2 and Smaller: Single turbine sensors.
- b. For Pipe Sizes NPS 2-1/2 and Larger: Dual turbine sensors.
- c. Piping with Bi-directional Flow: Bi-directional dual turbine sensors.
- d. Dual turbine sensors shall have dual, contra-rotating turbine elements, each turbine element with its own rotational sensing system, and an averaging circuit.
- e. Rotational sensing of each turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
- f. Sensor shall have an integral frequency output linear with flow rate. For dual turbine units, with individual top and bottom turbine outputs for diagnostic purposes.
- g. Bi-directional sensors shall have isolated solid-state dry contacts with a contact rating of 100 mA at 50 V. The contacts shall close when the flow in direction of arrow is 0.18 fps or more.
- h. Flow sensor shall be complete with installation hardware necessary to enable insertion and removal from pipe without system shutdown.
- i. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including installation hardware.
- j. House sensor electronics in a NEMA 250, Type 4 enclosure.
- k. Enclosure shall include connection(s) for field-installed conduit.
- l. Sensor shall have cable of length sufficient to connect to display module.
- m. Sensor housing shall have full port Type 316 stainless-steel ball valve for system isolation.

3. Display Module:

- a. Remote from sensor.
- b. House in a NEMA 250, Type 4X enclosure.
- c. Label terminal strip for all wiring connections.
- d. 120-V ac power supply with 24-V dc output to power the flow sensor.
- e. Remote Interface:
  - 1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
  - 2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
  - 3) Outputs linear to within 0.1 percent of calibrated span.
- f. Digital display for flow rate and totalized flow.
  - 1) At least eight display digits for totalization.
  - 2) Bi-directional units with separate digital display for flow and totalization in each direction.
- g. Local reset of flow totalization.
- h. Program and data shall be stored in nonvolatile memory in event of power loss.
- i. For bi-directional units, with display of flow direction (contacts open or closed).

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D. Inline Turbine Flow Meter:

1. Description:

- a. Available in NPS 3/4 and NPS 1.
- b. Operating pressure of 300 psig with a temperature of 200 deg F.
- c. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F.
- d. Pressure drop not to exceed 3 psig at 38 gpm.
- e. Sensor Accuracy:
  - 1) Within 2 percent of actual flow between the flow range of 0.8 to 38 gpm.
  - 2) Within 0.5 percent of actual reading at the calibrated velocity.
- f. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

2. Sensor:

- a. Rotational sensing of turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
- b. Sensor shall have an integral frequency output linear with flow rate.
- c. Sensor shall have threaded union on each end.
- d. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
- e. Construct wetted metal components of brass or stainless steel.
- f. House sensor electronics in a NEMA 250, Type 4 enclosure.
- g. Enclosure shall include connection(s) for field-installed conduit.
- h. Sensor shall have cable of length sufficient to connect to display module.

3. Display Module:

- a. Remote from sensor.
- b. Enclosure: NEMA 250, Type 4X.
- c. Label terminal strip for all wiring connections.
- d. 120-V ac power supply with 24-V dc output to power the flow sensor.
- e. Remote Interface:
  - 1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
  - 2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
  - 3) Outputs linear to within 0.1 percent of calibrated span.
- f. Digital display of flow rate and totalized flow.
- g. At least eight display digits for totalization.
- h. Local reset of flow totalization.
- i. Program and data shall be stored in nonvolatile memory in the event of power loss.

E. In-line Body Electromagnetic Flow Meter:

1. Description:

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- a. No moving parts.
    - b. Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.
    - c. Inherent bi-directional flow measurement.
    - d. Flow measurement with three pipe diameters upstream and two pipe diameters downstream.
    - e. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
    - f. Transmitter integral to remote from meter.
  2. Performance:
    - a. Accuracy for Velocities between 3.3 and 33 fps: Within 0.2 percent of reading.
    - b. Accuracy for Velocities between 1.0 and 3.3 fps: Within 0.75 percent of reading.
    - c. Accuracy for Velocities Less than 1.0 fps: Within 0.0075 fps.
    - d. Ambient Temperature: Minus 4 to plus 140 deg F.
    - e. Process Temperature: Minus 4 to 212 deg F.
    - f. Pressure: 225 psig.
  3. Analog Output Current Signal:
    - a. Two-wire, 4- to 20-mA dc current source.
    - b. Signal capable of operating into 1000-ohm load.
    - c. Isolated.
  4. Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.
  5. Operator Interface:
    - a. Keypad.
    - b. Digital Display: Multiple-line digital display of alphanumerical characters.
    - c. LED for normal and alarm operation.
  6. Construction:
    - a. Body: Epoxy-coated carbon steel.
    - b. Body Liner Material: PTFE.
    - c. Flow Tube: Type 304 stainless steel.
    - d. Connection: 150 Class flange.
    - e. Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
    - f. Electronics Enclosure:
      - 1) Painted aluminum.
      - 2) Removable cover.
      - 3) NEMA 250, Type 6.
- F. Insertion Electromagnetic Flow Meter:
1. Description:

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- a. No moving parts.
  - b. Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.
  - c. Suitable for pipe sizes NPS 3 through NPS 72.
  - d. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
  - e. Continuous auto-zero function.
  - f. Transmitter integral to meter.
2. Performance:
  - a. Flow Range: 0.25 to 20 fps.
  - b. Accuracy for Velocities between 2 and 20 fps: Within 1 percent of reading.
  - c. Accuracy for Velocities Less than 2 fps: Within 0.02 fps.
  - d. Ambient Temperature: Minus 5 to 150 deg F.
  - e. Process Temperature: 15 to 250 deg F.
  - f. Pressure: 400 psig.
3. Output Signals:
  - a. Field-selectable analog signals.
    - 1) Current Signal (Isolated): 4 to 20 mA.
    - 2) Voltage Signal (Isolated): Zero- to 10-V dc.
  - b. Digital Signal: Dry-contact closure signaling fault condition.
  - c. Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.
  - d. Scalable Pulse Output:
    - 1) Isolated solid-state dry contact.
    - 2) Contact Rating: 100 mA at 50-V dc.
    - 3) Pulse Duration: 0.5, 1, 2, or 6 seconds.
4. Construction:
  - a. Wetted Metal Parts: Type 316 stainless steel.
  - b. Sensor Head: Polysulfone.
  - c. Process Connection: 1-inch.
  - d. Instrument Isolation Valve: Full port Type 316 stainless-steel ball valve for system isolation.
  - e. Electrodes: Type 316 stainless steel.
  - f. Electronics Enclosure:
    - 1) Painted aluminum.
    - 2) Removable cover.
    - 3) NEMA 250, Type 4.
    - 4) Electrical Connection: PVC-jacketed cable, 10 feet long.
    - 5) Conduit Connection: 1/2-inch trade size.
5. Display Module:

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- a. Remote from meter.
- b. House in a NEMA 250, Type 4X enclosure.
- c. Label terminal strip for all wiring connections.
- d. 120-V ac power supply with 24-V dc output to power the flow sensor.
- e. Input Signal from Meter: Zero- to 15-V pulse output.
- f. Output Signals: Additional output signals furnished with flow meter connected to display module terminal strip.
- g. Auxiliary Output Signals: Analog current output (isolated) shall be 4 to 20 mA.
- h. Auxiliary Output Signals: Analog voltage output (isolated) shall be zero to 10 V.
- i. Auxiliary Output Signals: Digital output (isolated) shall be solid-state dry contacts rated for 100 mA at 50 V.
- j. Digital Display:
  - 1) Flow rate.
  - 2) Totalized flow.
  - 3) At least six display digits for flow rate and eight display digits for totalization.
  - 4) Bi-directional units with separate digital display for flow and totalization in each direction.
- k. Local reset of flow totalization.
- l. Program and data shall be stored in nonvolatile memory in the event of power loss.
- m. For bi-directional units, provide LED display of flow direction (contacts open or closed).

## 2.7 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

- A. Averaging Pitot Tubes:
  - 1. Standards: ASME MFC-12M.
  - 2. Description:
    - a. Sensor shall include isolation valves and connections that are suitable for connecting to a remote pressure instrument.
    - b. Sensor shall consist of high- and low-pressure plenums and be able to accommodate an integral RTD.
    - c. Sensor's cross-sectional tee shape shall allow flow separation at a fixed point independent of flow rate, pressure, or temperature with a stable flow coefficient maintained over a wide range of Reynolds numbers.
    - d. Sensor shape shall promote less-turbulent zones on the backside of the sensor. Individual sensing ports shall be located in this less-turbulent region to measure low pressure. Number of sensing ports shall be a function of the pipe size.
    - e. High pressure shall be measured by a frontal slot design extending full length of sensor. Number of slots shall be a function of pipe size.
    - f. Manufacturer shall submit on request independent testing documentation (product test reports), demonstrating compliance with specified performance.
- 3. Performance:
  - a. Discharge Coefficient Factor: Within 0.75 percent of flow rate.
  - b. Repeatability: Within 0.1 percent.

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- c. Flow Turndown: 10:1.
  - d. Sensor Size for Pipe Size NPS 2 through NPS 8: Minimum rod Reynolds number of 6000; probe width of 0.59 inch.
  - e. Sensor Size for Pipe Size NPS 6 through NPS 36: Minimum rod Reynolds number of 12500; probe width of 1.060 inch.
  - f. Sensor Size for Pipe Size NPS 12 through NPS 72: Minimum rod Reynolds number of 25000; probe width of 1.953 inches.
  - g. Process Temperature Limit: 500 deg F.
  - h. Process Pressure Limit: Equal to flange rating.
4. Construction:
- a. Sensor Surface Finish: Front surface textured for high-Reynolds-number applications to create a more turbulent boundary layer on front surface of sensor and produce a more predictable and repeatable separation of flow at edge of sensor.
  - b. Sensor Material: Type 316 stainless steel.
  - c. Packing Gland:
    - 1) Wetted Parts: Type 316 stainless steel.
    - 2) Packing Material: Graphite.
  - d. Isolation Valve: Type 316 stainless-steel full port ball valve configured to remove sensor while isolating process.
  - e. Flanged In-line Pipe Spool:
    - 1) Mount sensor in a flanged section of pipe.
    - 2) Pipe material to match adjacent pipe.
    - 3) Flanges to match adjacent pipe.
- B. Venturis:
- 1. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
  - 2. Standard: ASME MFC-3M.
  - 3. Performance:
    - a. Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.
    - b. Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.
    - c. Size and beta ratio shall be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.
4. Construction:
- a. One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2.
  - b. One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8, and fabricated steel with flanged connections for larger sizes.

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- c. Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.
- d. Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.
- e. Use venturi with pressure differential transmitter.

C. Portable Meter Package for Liquid Flow Sensors:

- 1. Metal-reinforced-plastic carrying case.
- 2. Waterproof meter with nominal 6-inch round dial face.
- 3. Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.
- 4. Meter with external range and zero adjustment.
- 5. Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.
- 6. Two connecting hoses, 10-feet long, with quick connect couplings compatible with venturi couplings.
- 7. Two brass blowdown valves with Buna-N seals and blowdown hoses.
- 8. Instruction book with flow versus differential curves.
- 9. Suitable for working pressure of 200 psig at 200 deg F.
- 10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.
- 11. Turn over to Owner at Project completion.

## 2.8 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

- 1. Description:
  - a. Field-adjustable four-vane combinations.
  - b. Field-adjustable set-point adjustment screw.
  - c. Suitable for pipe sizes NPS 1 through NPS 8.
  - d. Switch mounted vertically in horizontal pipe.
- 2. Performance:
  - a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
  - b. Pressure Limit: 145 psig.
  - c. Temperature Limit: 230 deg F.
  - d. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
  - e. Switch Type: SPDT snap switch.
- 3. Wetted Parts Construction:
  - a. Bellows: Tin-bronze.
  - b. Vanes: Stainless steel.
  - c. Body: Forged brass.
  - d. Process Connection: NPS 1.



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4. Enclosure:
  - a. Die-cast aluminum alloy.
  - b. NEMA 250, Type 4.
  - c. Electrical Connection: Cable gland with attached wire leads.
- B. Liquid Flow Switch (Magnetic Type):
  1. Description:
    - a. Field-adjustable five-vane combinations.
    - b. Suitable for pipe sizes NPS 1-1/2 through NPS 20.
    - c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe, or switch horizontally mounted in vertical pipe with flow up.
    - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.
  2. Performance:
    - a. Flow Rate Actuation and De-actuation: Varies with vane combination.
    - b. Pressure Limit: 1000 psig for brass body, 2000 psig for Type 316 stainless-steel body.
    - c. Temperature Range: Minus 4 to plus 275 deg F.
    - d. Electrical Rating: 10 A at 125/250-V ac.
    - e. Switch Type: SPDT snap switch.
  3. Wetted Parts Construction:
    - a. Vanes: Type 316 stainless steel.
    - b. Body: Type 316 stainless steel.
    - c. Magnetic Keeper: Type 316 stainless steel.
    - d. Process Connection: NPS 1-1/2.
  4. Enclosure:
    - a. Die-cast aluminum alloy.
    - b. Threaded cover.
    - c. NEMA 250, Type 4.
    - d. Electrical Connection: Terminal block.
    - e. Conduit Connection: 3/4-inch trade size.

## 2.9 LIQUID FLOW TRANSMITTERS

- A. Liquid Pressure Differential Transmitter for Flow Measurement:
  1. Performance:
    - a. Range: Approximately 2 times the set point.
    - b. Span: Adjustable plus or minus 1 mA, non-interactive.
    - c. Accuracy: Within 0.25 percent of full scale.

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- d. Maximum Operating Pressure: 2.5 times range.
  - e. Temperature Limits: Zero to 175 deg F.
  - f. Compensate Temperature Limits: 30 to 150 deg F.
  - g. Thermal Effects: 0.02 percent of full scale per degree F.
  - h. Response Time: 30 to 50 ms.
  - i. Shock and vibration shall not harm the transmitter.
- 2. Analog Output Current Signal:
  - a. Two wire, 4- to 20-mA dc current source.
  - b. Signal capable of operating into 1000-ohm load.
- 3. Operator Interface:
  - a. Zero and span adjustments located behind cover.
  - b. Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.
- 4. Construction:
  - a. Aluminum and stainless-steel enclosure with removable cover.
  - b. Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.
  - c. NPS 1/4 process connections on side of instrument enclosure.
  - d. Knock out for 1/2-inch trade size conduit connection on side of instrument enclosure.
  - e. Screw terminal block for wire connections.
  - f. NEMA 250, Type 4X.
  - g. Mounting bracket shall be suitable for installation.
- 5. Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 process connections.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

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1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
  2. Do not begin installation without submittal approval of mounting location.
- E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
- F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTRUMENT APPLICATIONS**

- A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
- B. Duct-Mounted Airflow Sensors:
1. Measured Velocities 500 fpm and Less: Thermal airflow station.
  2. Measured Velocities Greater than 500 fpm: Pitot-tube airflow sensor station or Thermal airflow station.
- C. Damper-Mounted Airflow Sensors:
1. Measured Velocities 400 fpm and Less: Thermal airflow station.
  2. Measured Velocities Greater than 500 fpm: Pitot-tube airflow sensor station or Thermal airflow station.
- D. Fan-Mounted Airflow Sensors:
1. Measured Velocities 500 fpm and Less: Thermal airflow station.
  2. Measured Velocities Greater than 500 fpm: Pitot-tube fan inlet airflow sensor station, Piezometer ring fan inlet airflow sensor or Thermal airflow station.
- E. Airflow Switches:
1. Measured Velocities 400 fpm and Less: Polymer film sail switch.
  2. Measured Velocities Greater than 400 fpm: Stainless-steel single-vane switch.
- F. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:
1. Exhaust Air Airflow: Pressure differential transmitter for airflow measurement.
  2. Outdoor Air Airflow: Pressure differential transmitter for airflow measurement.
  3. Return Air Airflow: Pressure differential transmitter for airflow measurement.
  4. Supply Air Airflow: Pressure differential transmitter for airflow measurement.
- G. Liquid Flow Sensors (Primary Elements):
1. Hydronic System, Chilled and Heating Hot Water: Averaging pitot tubes or Venturis.

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H. Liquid Flow Meters:

1. Hydronic System, Chilled and Heating Hot Water: Insertion turbine flow meter or Electromagnetic flow meter.

I. Liquid Flow Switches:

1. Hydronic System, Chilled and Heating Hot Water: Bellows type or Magnetic type.

J. Liquid Flow Transmitters:

1. Hydronic System, Chilled and Heating Hot Water: Liquid pressure differential transmitter.

### **3.3 INSTALLATION, GENERAL**

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 50 lb force.
- D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

### **3.4 ELECTRIC POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### **3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS**

#### **A. Mounting Location:**

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

#### **B. Mounting Height:**

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
  - a. Make every effort to mount at 60 inches.

#### **C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.**

### **3.6 FLOW INSTRUMENTS INSTALLATION**

#### **A. Airflow Sensors:**

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

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B. Liquid Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:
  - a. Install system process connections full size of meter connection, but not less than NPS 1. Provide stainless-steel bushing if required to mate to system connection.
  - b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
  - c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than NPS 1. Install stainless-steel bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

### **3.7 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

### **3.8 CLEANING**

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

### **3.9 CHECKOUT PROCEDURES**

- A. Description:
  - 1. Check out installed products before continuity tests, leak tests, and calibration.
  - 2. Check instruments for proper location and accessibility.
  - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
  - 4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- B. Flow Instrument Checkout:
  - 1. Verify that sensors are installed correctly with respect to flow direction.
  - 2. Verify that sensor attachment is properly secured and sealed.
  - 3. Verify that processing tubing attachment is secure and isolation valves have been provided.
  - 4. Inspect instrument tag against approved submittal.
  - 5. Verify that recommended upstream and downstream distances have been maintained.

### **3.10 ADJUSTMENT, CALIBRATION, AND TESTING**

- A. Description:
  - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

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2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

### 3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.



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- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

**END OF SECTION 23 0923.14**



**SECTION 23 0923.23**

**PRESSURE INSTRUMENTS**

**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. Air-pressure sensors.
  - 2. Air-pressure switches.
  - 3. Air-pressure transmitters.
  - 4. Liquid-pressure switches.
  - 5. Liquid-pressure transmitters.
- B. Related Requirements:
  - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
  - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.23.

**1.3 DEFINITIONS**

- A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

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2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

## 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
  - a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.
2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:
  - a. Outdoors, Protected: Type 12.
  - b. Outdoors, Unprotected: Type 4.
  - c. Indoors, Heated with Filtered Ventilation: Type 2.
  - d. Indoors, Heated with Nonfiltered Ventilation: Type 12.

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- e. Indoors, Heated and Air-Conditioned: Type 1.
- f. Mechanical Equipment Rooms:
  - 1) Chiller and Boiler Rooms: Type 4.
  - 2) Air-Moving Equipment Rooms: Type 12.
- g. Localized Areas Exposed to Washdown: Type 4.
- h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
- i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

## 2.2 AIR-PRESSURE SENSORS

### A. Duct Insertion Static Pressure Sensor:

- 1. Insertion length shall be at 8 inches.
- 2. Sensor with four radial holes of 0.04-inch diameter.
- 3. stainless-steel construction.
- 4. Sensor with threaded end support, sealing washers and nuts.
- 5. Connection: NPS 1/4 compression fitting.
- 6. Suitable for flat oval, rectangular, and round duct configurations.

### B. Duct Insertion Static Pressure Sensor:

- 1. Sensor probe with two opposing orifices designed to reduce error-associated air velocity.
- 2. Sensor insertion length shall be 8 inches.
- 3. Construct sensor of 6061-T6 aluminum alloy or Type 304 stainless steel.
- 4. Connection: Threaded, NPS 1/8 swivel fitting for connection to copper tubing or NPS 1/4 barbed fitting for connection to polyethylene tubing.
- 5. Sensor probe attached to a mounting flange with neoprene gasket and two holes for fasteners.
- 6. Mounting flange shall suitable for flat oval, rectangular, and round duct configurations.
- 7. Pressure Rating: 10 psig.

### C. Duct Traverse Static Pressure Sensor:

- 1. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
- 2. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
- 3. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
- 4. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
- 5. Accuracy within 1 percent of actual operating static pressure.
- 6. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30 degree yaw and pitch.
- 7. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
- 8. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.

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9. Suitable for flat oval, rectangular, and round duct configurations.

D. Outdoor Static Pressure Sensor:

1. Provides average outdoor pressure signal.
2. Sensor with no moving parts.
3. NEMA 250, Type 4X enclosure.
4. Pressure Connection: Brass barbed fitting for NPS 1/4 tubing.
5. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.

E. Space Static Pressure Sensor for Wall Mounting:

1. White ABS plastic wall plate with integral sensing port to sense static pressure.
2. Wall plate provided with matching colored screws and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with brass union fitting for tubing connection.
4. Pressure rating: 10 psig.

F. Space Static Pressure Sensor for Recessed Ceiling Mounting:

1. Stainless-steel round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

G. Space Static Pressure Sensor for Exposed or Suspended Mounting:

1. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.
2. Stainless steel with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
4. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
5. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
6. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
7. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

## 2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Diaphragm operated to actuate an SPDT snap switch.

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- a. Fan safety shutdown applications: Switch with manual reset.
- 2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
- 3. Enclosure Conduit Connection: Knock out or threaded connection.
- 4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
- 5. High and Low Process Connections: Threaded, NPS 1/8.
- 6. Enclosure:
  - a. Dry Indoor Installations: NEMA 250, Type 1.
  - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
  - c. Hazardous Environments: Explosion proof.
- 7. Operating Data:
  - a. Electrical Rating: 15 A at 120- to 480-V ac.
  - b. Pressure Limits:
    - 1) Continuous: 45 inches wg.
    - 2) Surge: 10 psig.
  - c. Temperature Limits: Minus 30 to 180 deg F.
  - d. Operating Range: Approximately 2 times set point.
  - e. Repeatability: Within 3 percent.
  - f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.4 AIR-PRESSURE TRANSMITTERS

### A. Air-Pressure Differential Transmitter:

- 1. Performance:
  - a. Range: Approximately 2 times set point.
  - b. Accuracy: Within 0.5 percent of the full-scale range.
  - c. Hysteresis: Within 0.10 percent of full scale.
  - d. Repeatability: Within 0.05 percent of full scale.
  - e. Stability: Within 1 percent of span per year.
  - f. Overpressure: 10 psig.
  - g. Temperature Limits: Zero to 150 deg F.
  - h. Compensate Temperature Limits: 40 to 150 deg F.
  - i. Thermal Effects: 0.033 percent of full scale per degree F.
  - j. Shock and vibration shall not harm the transmitter.
- 2. Output Signals:
  - a. Analog Current Signal:

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- 1) Two-wire, 4- to 20-mA dc current source.
  - 2) Signal capable of operating into 800-ohm load.
- b. Analog Voltage Signal:
  - 1) Three wire, zero to 10 V.
  - 2) Minimum Load Resistance: 1000 ohms.
3. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
4. Operator Interface: Zero and span adjustments located behind cover.
5. Construction:
  - a. Plastic casing with removable plastic cover.
  - b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
  - c. Screw terminal block for wire connections.
  - d. Vertical plane mounting.
  - e. NEMA 250, Type 4.
  - f. Provide mounting bracket suitable for installation.

## 2.5 LIQUID-PRESSURE SWITCHES

### A. Liquid Gage Pressure Switch-Diaphragm Operated:

1. Diaphragm operated to actuate a SPDT or DPDT snap switch.
2. Electrical Connections: Screw terminal.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Internal hex nut set-point adjustment with enclosed set-point indicator and scale.
  - a. Process Connection: Threaded, NPS 1/4 or NPS 1/2.
5. Enclosure:
  - a. Dry Indoor Installations: NEMA 250, Type 1, 12.
  - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4X with drain.
  - c. Hazardous Environments: Explosion proof.
6. Operating Data:
  - a. Electrical Rating: 15 A at 120-, 240-, and 480-V ac.
  - b. Pressure Limits: 1200 psig.
  - c. Ambient Temperature Limits: Minus 30 to 180 deg F.
  - d. Process Temperature Limits: Minus 4 to 167 deg F.
  - e. Adjustable Operating Range: 10 to 150 psig.
  - f. Deadband: Adjustable.
7. Pressure Chamber Material: Aluminum or brass or stainless steel.



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8. Diaphragm Material: Buna-N or fluorocarbon.

B. Liquid-Pressure Differential Switch:

1. Description:

- a. Type 316 stainless-steel double opposing bellows operate to actuate an SPDT snap switch.
- b. Wetted materials: Type 316 stainless steel.
- c. Seal: Buna-N or Viton.
- d. Electrical Connections: Screw terminal.
- e. Enclosure Conduit Connection: Knock out or threaded connection.
- f. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
- g. High and Low Process Connections: Threaded, NPS 1/4.
- h. Enclosure: NEMA 250, Type 4 or 4X.
- i. Operating Data:
  - 1) Electrical Rating: 10 A at 120- to 240-V ac.
  - 2) Pressure Limits: Zero to 500 psig
  - 3) Ambient Temperature Limits: Minus 20 to 150 deg F.
  - 4) Process Temperature Limits: 20 to 300 deg F.
  - 5) Operating Range: 2 times set point, unless otherwise required by application.
  - 6) Deadband: Adjustable or fixed as required by application.
- j. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.6 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

1. Performance:

- a. Range: Approximately 2 times the set point.
- b. Span: Adjustable plus or minus one milliamp, noninteractive.
- c. Accuracy: Within 0.25 percent of full scale.
- d. Hysteresis: Within 0.1 percent of full scale.
- e. Repeatability: Within 0.05 percent of full scale.
- f. Maximum Working Pressure: 250 psig.
- g. Temperature Limits: Zero to 175 deg F.
- h. Compensate Temperature Limits: 30 to 150 deg F.
- i. Thermal Effects: 0.02 percent of full scale per degree F.
- j. Response Time: 30 to 50 ms.
- k. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:

- a. Two-wire, 4- to 20-mA dc current source.

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- b. Signal capable of operating into 1000-ohm load.
- 3. Analog Output Voltage Signal:
  - a. Three wire, zero to 10 V.
  - b. Minimum Load Resistance: 1000 ohms.
- 4. Operator Interface:
  - a. Zero and span adjustments located behind cover.
  - b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.
- 5. Construction:
  - a. Aluminum and stainless-steel enclosure with removable cover.
  - b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
  - c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
  - d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
  - e. Screw terminal block for wire connections.
  - f. NEMA 250, Type 4.
  - g. Mounting Bracket: Appropriate for installation.
- 6. Provide transmitter with three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Provide manifold with NPS 1/4 NPT process connections.

## **2.7 SOURCE QUALITY CONTROL**

- A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.
- B. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PRESSURE INSTRUMENT APPLICATIONS**

- A. Duct-Mounted Static Pressure Sensors:

- 1. Air-Handling System, Supply, Return, Exhaust and/or Outside Air: Duct insertion static pressure sensor Duct traverse static pressure sensor.

- B. Space Static Pressure Sensors:

- 1. Air-Handling System, Supply, Return, Exhaust and/or Outside Air: Space static pressure sensor for wall mounting Space static pressure sensor for recessed ceiling mounting Space static pressure sensor for exposed or suspended mounting.

- C. Air-Pressure Differential Switches:

- 1. Air-Handling System, Supply, Return, Exhaust and/or Outside Air: Air-pressure differential switch with dual scale adjustable set point.

- D. Air-Pressure Differential Transmitters:

- 1. Air-Handling System, Supply, Return, Exhaust and/or Outside Air: Air-pressure differential transmitter.

- E. Liquid Gage Pressure Switches:

- 1. Hydronic System, Chilled and Heating Hot Water: Liquid gage pressure switch, diaphragm operated, low pressure Liquid gage pressure switch, diaphragm operated.

- F. Liquid-Pressure Differential Switches:

- 1. Hydronic System, Chilled and Heating Hot Water: Liquid-pressure differential switch.

- G. Liquid-Pressure Differential Transmitters:

- 1. Hydronic System, Chilled and Heating Hot Water: Liquid-pressure differential transmitter with field-selectable range.

### **3.3 INSTALLATION, GENERAL**

- A. Install products level, plumb, parallel, and perpendicular with building construction.

- B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a 50lb force.

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- C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Fastening Hardware:
  - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
  - 2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
  - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
  - 1. Use products that are suitable for environment to which they are subjected.
  - 2. If possible, avoid or limit use of materials in corrosive environments.
  - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
  - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

### **3.4 ELECTRICAL POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### **3.5 PRESSURE INSTRUMENT INSTALLATION**

- A. Mounting Location:
  - 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

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2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
  3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
  4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
  5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
  6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
  7. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.
- B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- C. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
  2. Unless indicated on Drawings, locate sensors approximately 50 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
  3. Install mounting hardware and gaskets to make sensor installation airtight.
  4. Route tubing from the sensor to transmitter.
  5. Use compression fittings at terminations.
  6. Install sensor in accordance with manufacturer's instructions.
  7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.
- D. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
  2. Locate wall-mounted sensor in an inconspicuous location.
  3. Submit sensor location for approval before installation.
  4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
  5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
  6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
  7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
  8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

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E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 3/4. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.

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7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

### **3.6 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

### **3.7 CHECKOUT PROCEDURES**

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

### **3.8 ADJUSTMENT, CALIBRATION, AND TESTING**

- A. Description:
  1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
  2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
  3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
  4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
  5. Provide diagnostic and test equipment for calibration and adjustment.
  6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
  7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
  8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
  9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

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B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

**3.9 ADJUSTING**

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

**3.10 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

**END OF SECTION 23 0923.23**



**SECTION 23 0923.27**

**TEMPERATURE INSTRUMENTS**

**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. Air temperature sensors.
  - 2. Combination air temperature sensors and switches.
  - 3. Air temperature switches.
  - 4. Air temperature RTD transmitters.
  - 5. Liquid temperature sensors.
  - 6. High-end, commercial-grade, liquid temperature sensors.
  - 7. Liquid temperature switches.
- B. Related Requirements:
  - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
  - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.27.

**1.3 DEFINITIONS**

- A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- B. RTD: Resistance temperature detector.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product, including the following:

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1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  3. Product description with complete technical data, performance curves, and product specification sheets.
  4. Installation operation and maintenance instructions, including factors affecting performance.
- B. Shop Drawings:
1. Include plans, elevations, sections, and mounting details.
  2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include diagrams for power, signal, and control wiring.
  4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.
- C. Samples: For each exposed product installed in finished space.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Environmental Conditions:
1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
    - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.
  2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
    - a. Outdoors, Protected: Type 1.
    - b. Outdoors, Unprotected: Type 4.
    - c. Indoors, Heated with Filtered Ventilation: Type 2.

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- d. Indoors, Heated with Non-Filtered Ventilation: Type 1.
- e. Indoors, Heated and Air Conditioned: Type 1.
- f. Mechanical Equipment Rooms:
  - 1) Chiller and Boiler Rooms: Type 4.
  - 2) Air-Moving Equipment Rooms: Type 1.
- g. Localized Areas Exposed to Washdown: Type 4.
- h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 1.
- i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

## 2.2 AIR TEMPERATURE SENSORS

### A. Platinum RTDs: Common Requirements:

- 1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
- 2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
- 3. Performance Characteristics:
  - a. Range: Minus 50 to 275 deg F.
  - b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
  - c. Repeatability: Within 0.5 deg F.
  - d. Self-Heating: Negligible.
- 4. Transmitter Requirements:
  - a. Transmitter required for each 100-ohm RTD.
  - b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

### B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

- 1. 100 or 1000 ohms.
- 2. Temperature Range: Minus 50 to 275 deg F
- 3. Probe: Single-point sensor with a stainless-steel sheath.
- 4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
- 5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
- 6. Gasket for attachment to duct or equipment to seal penetration airtight.
- 7. Conduit Connection: 1/2-inch

### C. Platinum RTD, Air Temperature Averaging Sensors:

- 1. 100 or 1000 ohms.
- 2. Temperature Range: Minus 50 to 275 deg F
- 3. Multiple sensors to provide average temperature across entire length of sensor.
- 4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.

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5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
  - a. Range: Minus 50 to 275 deg F.
  - b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
  - c. Repeatability: Within 0.5 deg F.
  - d. Drift: Within 0.5 deg F over 10 years.
  - e. Self-Heating: Negligible.
4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2-inch trade size.

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H. Thermistor Averaging Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size.

I. Thermistor Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch trade size.

J. Thermistor Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. 100- or 1000-ohm platinum RTD or thermistor.
2. Thermistor:
  - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
  - b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.
3. Temperature Transmitter Requirements:
  - a. Mating transmitter required with each 100-ohm RTD.
  - b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
  - a. Local override to turn HVAC on.

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- b. Local adjustment of temperature set point.
- c. Both features shall be capable of manual override through control system operator.

## **2.3 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH**

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. Combination temperature sensor and switch in same instrument.
- C. Air Temperature Switch:
  - 1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
  - 2. Responsive to coldest 12-inch section of sensor length.
  - 3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual reset at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.
- D. Air Temperature Sensor:
  - 1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
  - 2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
  - 3. Accuracy: Within 0.9 deg F.
  - 4. Output Signal: 4 to 20 mA for connection to remote monitoring.
  - 5. Encase RTDs in a flexible nominal 0.375-inch-diameter sheath constructed of brass.
  - 6. Lead wires shall be 18-gage AWG copper.
  - 7. Enclosure: NEMA 250, Type 4.

## **2.4 AIR TEMPERATURE SWITCHES**

- A. Thermostat and Switch for Low Temperature Control in Duct Applications:
  - 1. Description:
    - a. Two-position control.
    - b. Field-adjustable set point.
    - c. Manual reset.
    - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Performance:
    - a. Operating Temperature Range: 15 to 55 deg F.
    - b. Temperature Differential: 5 deg F, non-adjustable and additive.
    - c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
    - d. Sensing Element Maximum Temperature: 250 deg F.

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- e. Voltage: 120-V ac.
    - f. Current: 16 FLA.
    - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.
  - 3. Construction:
    - a. Vapor-Filled Sensing Element: Nominal 20 feet long.
    - b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
    - c. Set-Point Adjustment: Screw.
    - d. Enclosure: Painted metal, NEMA 250, Type 1.
    - e. Electrical Connections: Screw terminals.
    - f. Conduit Connection: 1/2-inch trade size.
- B. Thermostat and Switch for High Temperature Control in Duct Applications:
- 1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
  - 2. Description:
    - a. Two-position control.
    - b. Field-adjustable set point.
    - c. Manual reset.
    - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 3. Performance:
    - a. Temperature Range: 100 to 160 deg F.
    - b. Temperature Differential: 5 deg F.
    - c. Ambient Temperature: Zero to 260 deg F.
    - d. Voltage: 120-V ac.
    - e. Current: 16 FLA.
    - f. Switch Type: SPDT snap switch.
  - 4. Construction:
    - a. Sensing Element: Helical bimetal.
    - b. Enclosure: Metal, NEMA 250, Type 1.
    - c. Electrical Connections: Screw terminals.
    - d. Conduit Connection: 1/2-inch trade size.

## **2.5 AIR TEMPERATURE RTD TRANSMITTERS**

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. House electronics in NEMA 250 enclosure.
  - 1. Duct: Type 2.
  - 2. Outdoor: Type 4.

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- 3. Space: Type 1.
- C. Conduit Connection: 1/2-inch
- D. Functional Characteristics:
  - 1. Input:
    - a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
    - b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
  - 2. Span (Adjustable):
    - a. Space: 40 to 90 deg F.
    - b. Supply Air Cooling and Heating: 40 to 120 deg F.
    - c. Supply Air Cooling Only: 40 to 90 deg F.
    - d. Supply Air Heating Only: 40 to 120 deg F.
    - e. Exhaust Air: 50 to 100 deg F.
    - f. Return Air: 50 to 100 deg F.
    - g. Mixed Air: Minus 40 to 140 deg F.
    - h. Outdoor: Minus 40 to 140 deg F.
  - 3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .
  - 4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
  - 5. Match sensor with temperature transmitter and factory calibrate together.
- E. Performance Characteristics:
  - 1. Calibration Accuracy: Within 0.1 percent of the span.
  - 2. Stability: Within 0.2 percent of the span for at least 6 months.
  - 3. Combined Accuracy: Within 0.5 percent.

## 2.6 LIQUID TEMPERATURE SENSORS, COMMERCIAL GRADE

- A. RTD:
  - 1. Description:
    - a. Platinum with a value of 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg 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



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h. Performance Characteristics:

- 1) Range: Minus 40 to 210 deg F.
- 2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

1. Stem: Straight or stepped shank formed from solid bar stock.
2. Material: Brass or 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.

## 2.7 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Description:
  - a. Two-position control.
  - b. Field-adjustable set point.
  - c. Manual reset.
  - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Performance:
  - a. Operating Temperature Range: 65 to 200 deg F.
  - b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
  - c. Enclosure Ambient Temperature: 150 deg F.
  - d. Sensing Element Pressure Rating: 200 psig.
  - e. Voltage: 120-V ac.
  - f. Current: 8 FLA.
  - g. Switch Type: SPDT snap switch.
3. Construction:
  - a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
  - b. Temperature Scale: Fahrenheit, visible on face.
  - c. Set-Point Adjustment: Screw.
  - d. Enclosure: Painted metal, NEMA 250, Type 1.
  - e. Electrical Connections: Screw terminals.
  - f. Conduit Connection: 3/4-inch.

## **2.8 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE**

- A. House electronics in NEMA 250, Type 4 enclosure.
- B. Enclosure Connection: 1/2-inch trade size.
- C. Functional Characteristics:
  - 1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
  - 2. Default Span (Adjustable):
    - a. Chilled Water: Zero to 100 deg F.
    - b. Condenser Water: Zero to 120 deg F.
    - c. Heating Hot Water: 32 to 212 deg F.
    - d. Heat Recovery: Zero to 120 deg F.
  - 3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
  - 4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
  - 5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.
- D. Performance Characteristics:
  - 1. Calibration Accuracy: Within 0.1 percent of the span.
  - 2. Stability: Within 0.2 percent of the span for at least 6 months.
  - 3. Combined Accuracy: Within 0.5 percent.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 TEMPERATURE INSTRUMENT APPLICATIONS**

- A. Air Temperature Sensors:
  - 1. Duct, Air-Handling Systems: Thermistor or 100-ohm platinum RTD.
  - 2. Outdoor, Air-Handling Systems: Thermistor or 100-ohm platinum RTD.
  - 3. Space, Air-Handling Systems: Thermistor or 100-ohm platinum RTD.
- B. Air Temperature Transmitters:
  - 1. Duct, Air-Handling Systems: Air temperature RTD transmitter.
  - 2. Outdoor, Air-Handling Systems: Air temperature RTD transmitter.
  - 3. Space, Air-Handling Systems: Air temperature RTD transmitter.
- C. Liquid and Steam Temperature Sensors:
  - 1. Hydronic System, Chilled and Heating Hot Water: Liquid and steam temperature sensor, commercial grade.
- D. Liquid and Temperature Transmitters:
  - 1. Hydronic System, Chilled and Heating Hot Water: Liquid and steam temperature transmitter, commercial grade.

### **3.3 INSTALLATION, GENERAL**

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a 50lb force.
- C. Fastening Hardware:
  - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
  - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
  - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
  - 1. Use products that are suitable for environment to which they are subjected.
  - 2. If possible, avoid or limit use of materials in corrosive environments.

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3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

### **3.4 ELECTRIC POWER**

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

### **3.5 TEMPERATURE INSTRUMENT INSTALLATIONS**

- A. Mounting Location:
  1. Roughing In:
    - a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
    - b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
      - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
      - 2) Do not begin installation without submittal approval of mounting location.
    - c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
  2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
  3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
  4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

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5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Special Mounting Requirements:
1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
  2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
- C. Mounting Height:
1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
  2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
    - a. Make every effort to mount at 60 inches.
- D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- E. Space Temperature Sensor Installation:
1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
  2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
  3. In finished areas, recess electrical box within wall.
  4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
  5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
- F. Outdoor Air Temperature Sensor Installation:
1. Mount sensor in a discrete location facing north.
  2. Protect installed sensor from solar radiation and other influences that could impact performance.
  3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.
- G. Single-Point Duct Temperature Sensor Installation:

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1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:
  - a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
  - b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
  - c. Minimum insertion depth shall be 2-1/2 inches.
4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.

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8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor, service platform or catwalk.

### **3.6 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

### **3.7 CLEANING**

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

### **3.8 CHECK-OUT PROCEDURES**

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check temperature instruments for proper location and accessibility.
- C. Verify sensing element type and proper material.
- D. Verify location and length.
- E. Verify that wiring is correct and secure.

### **3.9 ADJUSTMENT, CALIBRATION, AND TESTING**

- A. Description:
  1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
  2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
  3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

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4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

### **3.10 ADJUSTING**

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

### **3.11 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.



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- B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:
  - 1. Software programming.
  - 2. Calibration and test procedures.
  - 3. Operation and maintenance requirements and procedures.
  - 4. Troubleshooting procedures.
- C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- D. Record videos on DVD disks.
- E. Owner shall have right to make additional copies of video for internal use without paying royalties.

**END OF SECTION 23 0923.27**



**SECTION 23 0993.11.51**

**SEQUENCE OF OPERATIONS FOR HVAC DDC (GUILFORD HIGH SCHOOL)**

**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 control sequences for DDC for HVAC systems, subsystems, and equipment.
- B. Related Requirements:
  - 1. Section 230923 "DDC Systems for HVAC" for control equipment.

**1.3 DEFINITIONS**

- A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).
- B. Binary Output: On/off output signal or contact closure.
- C. DDC: Direct digital control.
- D. Digital Output: Data output that must be interpreted digitally.

**1.4 ACTION SUBMITTALS**

- A. Product Data:
  - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
  - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.
- B. Shop Drawings:
  - 1. Riser diagrams showing control network layout, communication protocol, and wire types.
  - 2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.

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3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

## 1.5 CHILLED WATER SYSTEM PRIMARY/SECONDARY PUMPING

- A. Chilled Water System Description – The chilled water system is a nominal 600 ton system comprised of three (3) 200 ton air-cooled chillers operating in parallel. The system is designed as a primary-secondary pumping system with each chiller provided with a dedicated primary pump. The design is intended to provide constant flow through the air-cooled chillers utilizing the primary pumps while allowing variable flow to occur through the secondary loop utilizing a separate pair of secondary chilled water pumps. The chilled water system includes remote evaporators located in the penthouse.
- B. Operator interface - The chilled water control system shall include the following operator interface elements:
  1. Operational status screen to include:
    - a. Chiller System Status (Off/Soft Start/Normal/Ambient Lockout/Shutdown in Progress)
    - b. Chiller Plant Supply Water Set-point
    - c. Chilled Water System Supply Water Temperature
    - d. Chilled Water System Return Water Temperature
    - e. Predictive chiller addition / subtraction status messages (i.e. "Next Chiller will be added if the system supply water temp [ 41.7 ] exceeds [ 43.5 ] degrees for [ 10 ] minutes." Or "Next Chiller will be subtracted if there is no add request and the actual system Delta T [ 10.7 ] degrees is less than [ 7.5 ] degrees for [ 10 ] minutes.")
    - f. Individual Chiller Failure Reset (Push Button)
    - g. All Chiller Failure Reset (Push Button)
    - h. Manual Addition of Chiller (Push Button)
    - i. Manual Subtraction of Chiller (Push Button)
    - j. Manual Rotation of Chiller Sequence (Push Button)
  2. Screen that allows editing of the following data (to be performed without entering program code editor):
    - a. Supply Water Setpoint
    - b. System Soft Loading Parameters
    - c. Ambient Lockout Parameters
    - d. Chiller Addition Parameters
    - e. Chiller Subtraction Parameters
    - f. Auto Rotation Parameters
    - g. Alarm Handling Setup
    - h. Security Setup
  3. Individual Chiller Graphic(s) to include all data listed on the supplementary Chiller System Point List, including:
    - a. Chiller Name

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- b. Chiller Operating Mode
  - c. Chilled Water Setpoint
  - d. Chiller RLA %
  - e. Entering Chiller Water Temperature
  - f. Leaving Chilled Water Temperature
  - g. Evaporator Flow Status
- C. System Start/Stop - The chilled water system shall start in response to a binary signal from an external source such as the building automation system. The intent is for the chilled water system to be initiated manually by facilities personnel.
  - 1. Upon the start of the chilled water system the chiller plant control system shall automatically start Trend Log Reports to include:
    - a. Hourly logging of system shall include the following points:
    - b. Outside Air Dry Bulb
    - c. System Chilled Water Set-point
    - d. System Chilled Water Supply
    - e. System Chilled Water Return Temperature
    - f. Operating Status of each chiller
    - g. Operating Status of pumps
- D. Sequencing - The chiller plant control system will start and stop the chilled water pump(s) and chiller based upon system load. The air-cooled chillers identified as CH-1, CH-2 and CH-3 on the mechanical plans shall be controlled in parallel utilizing a lead-lag approach that prioritizes operation so the chillers are rotating lead-lag on a monthly basis with the goal being to equalize run time.
  - 1. When the chilled water system is enabled the chiller plant control system shall:
    - a. Send an Enable signal to the lead chiller.
    - b. Upon receiving the enable signal the chiller shall enable its chilled water pump.
    - c. Upon confirmation of evaporator water flow the chiller shall continue its pre-start sequence and start its compressor(s).
    - d. Upon the start of each chiller the Chiller Plant Control system shall automatically start chiller specific Trend Log Reports to include:
      - 1) Hourly logging of chiller
      - 2) Unit Chilled Water set-point
      - 3) Compressor(s) RLA
      - 4) Evaporator Entering Water Temp
      - 5) Evaporator Leaving Water Temp
      - 6) Evaporator Approach Temp
      - 7) Five-minute logging of chiller:
      - 8) Unit Chilled Water set-point
      - 9) Compressor(s) RLA
      - 10) Evaporator Entering Water Temp
      - 11) Evaporator Leaving Water Temp
  - 2. The chiller water system controller shall initiate the start of the next chiller in the sequence whenever insufficient chilled water capacity exists continuously, as indicated

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by supply water temperature deviation from system chilled water temperature set-point, is not met for [ 20 ] minutes.

- a. The chiller plant control system will unload operating chillers to an operator editable current limit prior to starting a lag chiller.
    - b. Lag chillers shall start in a similar manner to the lead chiller start sequence.
  3. The chiller plant control system shall initiate the shut-down of the next chiller in the sequence whenever excess chilled water capacity, as determined by the system supply and chiller return water temperatures, exists for [ 20 ] minutes.
  4. The chiller shall shut down its pump when the chiller determines it is safe to do so.
  5. Upon sensing a chiller failure the chiller plant control system shall shut down the failed chiller immediately and initiate the start of the next chiller in the rotation sequence.
  6. The chiller plant control system shall control individual chiller set-points to maintain the system supply water temperature at set-point.
  7. The design system chilled water set-point shall be [42] degrees F and editable by the operator.
  8. Reset of the system chilled water supply temperature upward shall be allowed only when a single chiller is operating. The maximum reset chilled water set-point shall be [5] degrees F above the base set-point. Reset shall be accomplished using critical valve position.
    - a. The system chilled water supply temperature shall not be reset if the space relative humidity rises above [60% RH] as measured by space humidity sensors.
- E. System Soft Start - The chiller plant control system will initiate a "soft start" mode whenever the system chilled water temperature exceeds the specified chilled water system set-point by [ 20 ] degrees F at system start-up. The chiller plant control application will add cooling capacity during soft start mode only if return water temperature is not declining at a rate of at least [ 0.5 ] degrees F per minute. This prevents the unnecessary operation of chillers and limits system electrical demand during chilled water loop pull down.
- F. Diagnostics/Protection - the Building Automation System shall be able to alarm from all sensed points and diagnostic alarms monitored by the chiller controller.
- A. CHILLED WATER SYSTEM Control Point List
1. Digital Outputs
    - a. Primary CHWP-1 Start/Stop
    - b. Primary CHWP-2 Start/Stop
    - c. Primary CHWP-3 Start/Stop
    - d. Secondary CHWP-4 Start/Stop
    - e. Secondary CHWP-5 Start/Stop
    - f. Secondary CHWP-6 Start/Stop
    - g. CH-1 Start/Stop
    - h. CH-2 Start/Stop

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- i. CH-3 Start/Stop
- 2. Digital Inputs
  - a. Primary CHWP-1 Status/Alarm
  - b. Primary CHWP-2 Status/Alarm
  - c. Primary CHWP-3 Status/Alarm
  - d. Secondary CHWP-4 Status/Alarm
  - e. Secondary CHWP-5 Status/Alarm
  - f. Secondary CHWP-6 Status/Alarm
  - g. CH-1 Status/Alarm
  - h. CH-2 Status/Alarm
  - i. CH-3 Status/Alarm
- 3. Analog Inputs
  - a. Primary CHWP-1 Speed Feedback HZ
  - b. Primary CHWP-2 Speed Feedback HZ
  - c. Primary CHWP-3 Speed Feedback HZ
  - d. Secondary CHWP-4 Speed Feedback HZ
  - e. Secondary CHWP-5 Speed Feedback HZ
  - f. Secondary CHWP-6 Speed Feedback HZ
  - g. CH-1 Evaporator Entering Temperature
  - h. CH-1 Evaporator Leaving Temperature
  - i. CH-2 Evaporator Entering Temperature
  - j. CH-2 Evaporator Leaving Temperature
  - k. CH-3 Evaporator Entering Temperature
  - l. CH-3 Evaporator Leaving Temperature
  - m. Chilled Water Supply Temperature
  - n. Chilled Water Return Temperature
  - o. Differential Pressure Sensor 1
  - p. Differential Pressure Sensor 2
  - q. Make-up Water Meter
  - r. CHWP-1 Flow Meter
  - s. CHWP-2 Flow Meter
  - t. CHWP-3 Flow Meter
  - u. De-coupler Flow Meter
  - v. Secondary CHW Flow Meter
- 4. Analog Outputs
  - a. Secondary CHWP-4 Speed Control
  - b. Secondary CHWP-5 Speed Control
  - c. Secondary CHWP-6 Speed Control

**1.6 HOT WATER REHEAT SYSTEM (HWP-3/HWP-4/HX-3) CONTROL SEQUENCE**

- A. System Start/Stop
  - 1. The hot water reheat system shall operate continuously. It shall be manually enabled and disabled by RPS facilities personnel.
  - 2. Upon the start of the hot water system the BAS shall automatically start Trend Log Re-

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ports to include:

- a. Outdoor Air Dry Bulb
- b. System Hot Water Set-Point
- c. System Hot Water Supply
- d. System Hot Water Return Temperature
- e. Operating Status of Hot Water Pumps

B. Steam-Hot Water Heat Exchanger:

1. The heating system controller shall sense the hot water supply temperature leaving the heat exchanger and shall modulate steam control valve on the steam supply to the heat exchanger, in sequence, to maintain the required hot water supply temperature.
2. The BAS shall reset the Hot Water Temperature set point based on outdoor air temperature.

Make this reset linear

Outdoor Air Temperature = 60 deg F then the Hot Water Temperature set-point = 120 deg F.

Outdoor Air Temperature = 20 deg F then the Hot Water Temperature set-point = 180 deg F.

C. HOT WATER PUMP CONTROL

1. The hot water pump operation shall be continuous. One pump serves as the lead pump and the second pump serves as an automatic standby. On a loss of hot water flow the standby pump shall start and an alarm shall be generated at the BAS workstation.
2. The lead/standby pumps shall alternate monthly.
3. The hot water pumps are equipped with VFDs. Hot water supply and return differential pressure sensors shall sense the hot water supply and return pressure and control the lead pump VFD to maintain the required differential pressure across the hot water heating system.
4. The differential pressure sensing points shall be located as shown on the drawings.

D. HOT WATER REHEAT SYSTEM DDC Control Point List

1. Digital Outputs
  - i. HWP-3 VFD Start/Stop
  - ii. HWP-4 VFD Start/Stop
2. Digital Inputs
  - i. HWP-3 VFD Status
  - ii. HWP-4 VFD Status
  - iii. HWP-3 VFD Alarm
  - iv. HWP-4 VFD Alarm
3. Analog Inputs



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- i. Hot Water Supply Temperature
- ii. Hot Water Return Temperature
- iii. Differential pressure sensor
- iv. HWP-3 VFD Speed Feedback
- v. HWP-3 VFD Speed Feedback
- vi. Make-Up Water Meter

4. Analog Outputs

- i. Steam Control Valve
- ii. HWP-3 VFD Pump Speed
- iii. HWP-4 VFD Pump Speed

Note: In addition to hard-wired VFD points identified above, provide network communication interface with each VFD to provide additional information to the BAS.

**1.7 AIR HANDLING UNIT AHU-1A (LOCKER ROOMS)**

- A. Air handling unit AHU-1A is a 100% OA variable volume system with supply fan, return fan, outside air (normally closed), relief air (normally closed) and return air (normally open) mixing dampers, preheat coil and chilled water cooling coil. The air handling unit supplies low pressure supply air to Wrestling Room, Aerobics Room & Locker Rooms. The air handling unit supplies medium pressure air to VAV boxes with reheat serving Wrestling Room, Aerobics Room & Locker Rooms.
- B. The air handling unit shall run continuously during the occupied mode.
- C. Discharge Air Control: The air handling unit controller shall sense the discharge air temperature and control the hot water preheat coil with internal face and bypass dampers and chilled water coil to maintain 55 deg. F. (adj.) discharge air temperature as follows:
  - 1. On a call for heating the preheat coil control valve shall modulate to maintain the discharge air temperature. The bypass damper shall remain fully closed.
  - 2. When the mixed air temperature drops below 40 deg F the control valve shall modulate to the fully open position and the face and bypass dampers shall modulate to maintain discharge air temperature.
  - 3. A flow switch shall in the return pipe to the preheat coil shall sense hot water flow. Upon a loss of flow the hot water re-circulating pump HWRP-1 shall be commanded on and an alarm shall be generated indicating loss of flow.
  - 4. If the hot water re-circulating pump is commanded on and the flow switch does not detect water flow the supply fan shall stop and an alarm shall be generated indicated pump failure.
  - 5. On a call for cooling the chilled water control valve shall modulate to maintain discharge air temperature. Mechanical cooling shall be locked out below 55 deg. F. (adj.) outside air temperature and when the supply fan is off.
- D. Building Pressure Control: Barometric Relief. No DDC control.
- E. Unoccupied Mode:
  - 1. When the air handling unit is indexed to the unoccupied mode from the air handling unit controller, downloaded from the operator workstation, the supply fan shall stop and the outside air damper shall close. When the supply fan is off during the unoccupied mode the preheat coil control valve shall be under control of the mixed air temperature sensor and maintain a fan plenum temperature of 65 deg, F. (adj.).

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2. On a call for heat during the unoccupied heating season the supply fan shall cycle to maintain a reduced room temperature of 65 deg. F. (adj.).
  3. On a call for cooling during the unoccupied cooling season the supply fan shall cycle to maintain a high limit room temperature of 85 deg. F. (adj.). When the supply fan runs during the unoccupied cooling mode the mechanical cooling shall operate and shall be controlled as described for the occupied mode.
  4. During the unoccupied mode a sensor located in the waiting room shall be the input for the reduced/high limit temperature setting.
  5. The unoccupied mode for either heating or cooling shall be individually activated through a BAS workstation command.
  6. Warm-Up (heating season only):
    - a. When the air handling unit is indexed to the occupied mode from the air handling unit controller the supply fan shall start until the return air temperature reaches 68 deg. F. (adj.).
    - b. The system shall then return to the occupied mode.
- F. Safety Control:
1. When mixed air temperature drops below 35 deg F the existing hot water control valve shall be commanded on to maintain full hot water flow through the preheat coil at all times.
  2. If the discharge air temperatures drops below 35 F with the control valve 100% open, the supply fan shall stop and the outside air damper shall close.
  3. When the fire alarm system is in alarm the supply fan shall stop.
- G. AHU-1A DDC Control Point List
1. Digital Outputs
    - a. Supply Fan Start/Stop
    - b. Outdoor Air Damper
    - c. Hot Water Recirculating Pump Start/Stop
  2. Digital Inputs
    - a. Supply Fan Status/Alarm
    - b. Hot Water Recirculating Pump Status/Alarm
    - c. Low Limit Device
    - d. Pre-Filter Differential Pressure Switch
    - e. Preheat Coil Flow Switch
    - f. Supply Air Duct Smoke Detector Status
    - g. Return Air Duct Smoke Detector Status
  3. Analog Inputs
    - a. Supply Fan VFD Feedback (Hz)
    - b. Return Fan VFD Feedback (Hz)
    - c. AHU Supply Air Temperature
    - d. Preheat Coil Discharge Air Temperature
    - e. Outdoor Air Temperature (may be global)
    - f. Outdoor Air Humidity (may be global)

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- 4. Analog Outputs
  - a. Supply Fan VFD Control
  - b. Return Fan VFD Control
  - c. Chilled Water Control Valve
  - d. Preheat Coil Control Valve
  - e. Face & Bypass Damper

**1.8 ALTERNATE BID NO. 2 – POOL DEHUMIDIFICATION UNIT PDU-1 (SERVING NATATORIUM)**

- A. The Pool Dehumidification Units shall be specifically designed for natatorium environmental control including dehumidification, filtration, ventilation, heating and cooling. The unit shall have fully self-contained microprocessor controller with diagnostics, status reporting and alarm functions and a BACnet communications card to allow interface with the new Building Automation System. All available control points, data and information from the pool dehumidification units shall be uploaded to the Building Automation System and populated onto graphic screens to allow facility operators to observe system performance and make set-point adjustments of space temperature.
- B. The Pool Dehumidification Unit shall have the capability to control external components such as pool exhaust fans and duct mounted hot water reheat coils. These items are not intended to be independently controlled by the BAS however the BAS shall provide exhaust fan status for pool exhaust fans to provide alarms in the event of exhaust fan failure.

**1.9 AIR-HANDLING UNITS AHU-1C & 1D (SOUTH GYMNASIUM)**

- A. Air handling unit AHU-1C and 1D are variable volume units equipped with supply fan, return fan, outside air (normally closed), relief air (normally closed) and return air (normally open) mixing dampers, preheating coil and chilled water cooling coil. The air handling unit supplies medium pressure air to VAV boxes with reheat serving the South Gym and adjacent areas.
- B. The air handling unit shall run continuously during the occupied mode. The air handling unit supply fan and return fan shall be interlocked. When the supply fan runs the return fan shall also run.
- C. Discharge Air / Economizer Control: The air handling unit controller shall sense the discharge air temperature and control the pre-heat coil, chilled water cooling coil and mixing dampers in sequence to maintain 53 deg. F. (adj.) at the discharge of the cooling coil as follows:
  - 1. The outside air, return air and exhaust air dampers shall modulate to maintain the discharge air temperature. A mixed air sensor shall maintain a low limit mixed air temperature of 40 deg. F.(adj.) except the outside air damper shall remain at its minimum position on a call for less outside air.
  - 2. On a call for heating, when the outside air damper is at its minimum position, the preheat coil control valve shall modulate to maintain the discharge air temperature.
  - 3. On a call for cooling the outside air, return air and exhaust dampers shall modulate to increase the outside air intake. When the outside air damper is at the 100% open position and the discharge air temperature continues to rise the chilled water control valve shall modulate open. When mechanical cooling is operating it shall be controlled from discharge air temperature. When the outside air temperature is above 55 deg. F. (adj.) the outside air damper shall return to its minimum position. Mechanical cooling shall be locked out below 40 deg. F. (adj.) outside air temperature and when the supply fan is off.

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- D. The air handling unit controller shall sense the return air relative humidity and trend return air humidity for monitoring purposes only.
- E. Static pressure control: The air handling unit controller shall sense the supply air static pressure at a point 2/3 down the supply air duct and maintain a constant supply air static pressure by controlling the supply fan VFD. A second supply air static pressure sensor shall be located at the end of the longest duct run from the air handling unit. If the static pressure at the end of the duct run falls below a predetermined set point the end of duct run transmitter shall override to control the supply air static pressure. The control point of the end of duct run sensor shall be determined during system balancing. The set point shall be the critical low point where the terminal units can operate. On supply fan start-up the VFD shall begin controlling at minimum flow.
- F. Building Pressure Control: The air handling unit controller shall maintain positive building static pressure by controlling the return fan speed to track the supply fan speed and maintain a fixed offset of outdoor airflow as required to keep the space under positive pressure. On return fan start-up the VFD shall begin controlling at minimum flow.
- G. Demand Control Ventilation - CO2 Control:
  - 1. There shall be CO2 sensor installed in critical zones as indicated on drawings. When the CO2 level in a specific zone rises above the CO2 set-point (adjustable), the DDC controller will override the mixed air control and modulate the outdoor air dampers open until the CO2 level in that particular zone drops below the CO2 set-point (adjustable).
- H. Unoccupied Mode:
  - 1. When the air handling unit is indexed to the unoccupied mode from the air handling unit controller, downloaded from the operator workstation, the supply and exhaust fans shall stop, the outside air and exhaust air dampers shall close and the return air damper shall open. When the supply fan is off during the unoccupied mode the preheat coil control valve shall be under control of the mixed air temperature sensor and maintain a fan plenum temperature of 65 deg. F. (adj.).
  - 2. On a call for heat during the unoccupied heating season the supply and return fans shall cycle to maintain a reduced room temperature of 65 deg. F. (adj.).
  - 3. On a call for cooling during the unoccupied cooling season the supply and return fans shall cycle to maintain a high limit room temperature of 85 deg. F. (adj.). When the supply fan runs during the unoccupied cooling mode the mechanical cooling shall operate and shall be controlled as described for the occupied mode.
  - 4. During the unoccupied mode a sensor located in the waiting room shall be the input for the reduced/high limit temperature setting.
  - 5. The air handling unit shall circulate return air only when the fans run during the unoccupied mode.
  - 6. The unoccupied mode for either heating or cooling shall be individually activated through a BAS workstation command.
  - 7. Warm-Up (heating season only):
    - a. When the air handling unit is indexed to the occupied mode from the air handling unit controller the supply and return fans shall start and shall circulate return air only until the return air temperature reaches 68 deg. F. (adj.).
    - b. The system shall then return to the occupied mode.
- I. Safety Control:

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1. A low limit control located in the preheat coil discharge air shall stop the supply fan whenever the discharge air temperature falls below 35 deg. F. When the supply fan stops the return fan shall also stop, the outside air and exhaust air dampers shall close and the return air damper shall open.
2. A high limit static pressure switch in the supply fan discharge and a low limit static pressure switch in the return fan inlet shall stop the fans when their limits are exceeded.
3. When the fire alarm system is in alarm the supply and return fans shall stop.

J. AHU-1C & 1D DDC Control Point List

1. Digital Outputs

- a. Supply Fan Start/Stop
- b. Return Fan Start/Stop

2. Digital Inputs

- a. Supply Fan Status/Alarm
- b. Return Fan Status
- c. Low Limit Device
- d. Pre-Filter Differential Pressure Switch
- e. Low Limit Static Pressure Switch
- f. High Limit Static Pressure Switch
- g. Supply Air Duct Smoke Detector Status
- h. Return Air Duct Smoke Detector Status

3. Analog Inputs

- a. Supply Fan VFD Feedback (Hz)
- b. Return Fan VFD Feedback (Hz)
- c. AHU Supply Air Temperature
- d. Preheat Coil Discharge Air Temperature
- e. Return Air Temperature
- f. Return Air Humidity
- g. Outdoor Air Temperature (may be global)
- h. Outdoor Air Humidity (may be global)
- i. Supply Air Static Pressure
- j. Mixed Air Temperature

4. Analog Outputs

- a. Supply Fan VFD Control
- b. Return Fan VFD Control
- c. Chilled Water Control Valve
- d. Preheat Coil Control Valve
- e. Return Air Damper
- f. Outdoor Air Damper
- g. Relief Air Damper
- h. Outdoor Airflow Station
- i. Return Airflow Station
- j.

#### 1.10 AIR-HANDLING UNITS AHU-1E (CAFETERIA)

A. AHU-1E Control Sequence:

1. Air-Handling Units AHU-1E is variable volume unit that is equipped with dual supply fans, dual power exhaust fans, energy wheel, bypass dampers for economizer, outside air damper, return air damper, discharge isolation dampers, pre-heat coil, chilled water cooling coil and filter sections. The supply fans and exhaust fans are equipped with a variable frequency drive for variable volume operation, system balancing and soft start.
2. The supply fan will be started based on occupancy. When the supply fan status indicates the fan started, the control sequence will be enabled. The supply fan will operate at a variable speed to provide static pressure control.
3. Static pressure control: The air handling unit controller shall sense the supply air static pressure at a point 2/3 down the supply air duct and maintain a constant supply air static pressure by controlling the supply fan VFD. A second supply air static pressure sensor shall be located at the end of the longest duct run from the AHU. If the static pressure at the end of the duct run falls below a predetermined set point the end of duct run transmitter shall override to control the supply air static pressure. The control point of the end of duct run sensor shall be determined during system balancing. The set point shall be the critical low point where the terminal units can operate. On supply fan start-up the VFD shall begin controlling at minimum flow.
4. The control system shall coordinate the return/exhaust fan function with the supply fan and outdoor air damper. The return/exhaust fan shall be energized whenever the supply fan is on and the outdoor air damper is open. The exhaust fan shall operate at variable speed as required for building pressure control and remain energized until the supply fan is turned off.
5. Building pressure control: The air handling unit controller shall sense the building static pressure and shall control the return/exhaust fan VFD to maintain building static pressure at 0.02 - 0.05" w.g. to outside air. Separate static pressure transmitters shall sense building static pressure at one location in the building served by each AHU. The Temperature Control Subcontractor shall trend the static pressure readings on each floor for a period of 30 days and submit the trend for review and approval by the engineer. On return fan start-up the VFD shall begin controlling at minimum flow
6. Temperature control: The air-cooled condensing unit compressors shall stage on/off to maintain discharge air temperature at 53 deg F (adj.). Compressors shall be locked out when the outside air temperature drops below 45 F.
7. Energy Recovery Wheel Sequence of Operation: Energy wheel is equipped with bypass dampers on the supply and exhaust side with end switch to indicate full open, a variable frequency drive to control rotation speed, and a rotation detection module. All values will be displayed as 0% to 100% where 0% is open/minimum, and 100% is full open/maximum.

The energy wheel will be enabled/disabled with the air handling unit supply fan. When the air handling unit supply fan has proven "on" and the energy wheel variable frequency drive is not in fault the bas will send a start command to the energy wheel.

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The program will calculate the energy wheel's enthalpy, dewpoint, and wetbulb temperatures for the leaving supply side and the entering and leaving exhaust side. These values will be based on the respective temperature and humidity input values.

There will be four operational modes for the energy wheel

- Frost/Condensate Prevention Mode
- Heat Recovery Mode
- Cooling Recovery Mode
- Crawl Mode

Frost/Condensate Prevention Mode...Will be controlled with a direct acting proportional and integral loop with the loop out put represented in 0% to 100% units calculated with the deviation between the process set point and the process variable. The process set point will be the value of the energy wheel's calculated frost dewpoint plus five degrees F. The process variable will be represented by the value of the energy wheel's leaving exhaust temp.

Heat Recover Mode...Will be enabled by a dead band switch based on outdoor air temperature, "on" at 48 degrees F. And "off" at 52 degrees F. And will be controlled with a reverse acting proportional and integral loop with the loop out put represented in 0% to 100% units calculated with the deviation between the process set point and the process variable. The process set point is the value of the air handling unit's discharge air temperature set point. The process variable will be represented by the value of the energy wheel's leaving supply temperature. The command for the energy wheel's variable frequency drive will be the minimum value of the energy wheel accell ramp, frost/condensate prevention loop output, and the heat recovery loop output, and shall modulate to maintain setpoint.

Cooling Recovery Mode...Will be enabled by dead band switch based on outdoor air temperatures minus the air handling unit's return air temperature, "on" at 5 degrees F. Deviation and "off" at 2 degrees F. Deviation, and will be controlled with a direct acting proportional and integral loop with the loop out put represented in 0% to 100% units calculated with the deviation between the process set point and the process variable. The process set point is the value of the air handling unit's discharge air temperature set point. The process variable will be represented by the value of the energy wheel's leaving supply temperature. The command for the energy wheel's variable frequency drive will be the minimum value of the energy wheel accell ramp, frost/condensate prevention loop output, and the cooling recovery loop output, and shall modulate to maintain setpoint.

Crawl Mode...This mode will be enabled when both the heat recovery enable and the cooling recovery enable are 'off.' When the crawl mode is enabled the bypass dampers will ramp to 100% bypass, and the energy wheel's variable frequency drive will be commanded to minimum. When the heat recovery enable or the cooling recovery enable are "on" the crawl mode enable will be "off" and the bypass dampers will ramp to 0% bypass, and the energy wheel's variable frequency drive will modulate to maintain discharge air temperature set point.

Alarms...The bas will generate all alarms at the head end. The following will stop the energy wheel and open the bypass dampers to full bypass.

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- Energy wheel's variable frequency drive fault
- Energy wheel fails to prove status
- Rotation detection control module general alarm

System shut down...The bas will stop the energy wheel and open the bypass dampers to full bypass, set zero in all ramps and control outputs, and disable the rotation detection control module.

B. Discharge Air Reset:

1. The BAS shall manage the VAV air system such that the use of local reheat in the VAV boxes is minimized. This is accomplished through the use of Air handler supply fan discharge duct static pressure reset and discharge air temperature reset strategies.
2. When the VAV air system is in occupied cooling mode, the BAS shall continuously monitor the damper position of all VAV terminal units.
3. When the box with the most-open air damper position is less than 65% (adjustable) open:
  - a. The air handler's supply fan discharge duct static pressure set-point shall be reset downward by 0.1 in W.C. (adjustable), at a frequency of 10 minutes (adjustable) until the air damper of the VAV box is more than 65% (adjustable) open, or the static pressure set-point has reset downward to the system minimum duct static pressure set-point, or the AHU variable-frequency drive is at the minimum speed setting.
  - b. When the static pressure set-point has been reset downward to the system minimum duct static pressure set-point, or the AHU variable-frequency drive is at the minimum speed setting and the air damper of the VAV box remains less than 65% (adjustable), the air handler's discharge air temperature set-point shall be reset upward in increments of 1°F (adjustable) until the air damper of the VAV box is more than 65% (adjustable) open, or until the discharge air set-point is reset to the maximum setting of 60°F (adjustable).
4. When any VAV damper is more than 75% (adjustable) open:
  - a. The air handler's discharge air temperature set-point shall be reset downward in increments of 1°F (adjustable) until no damper is more than 75% open or until the discharge air set-point is reset to the minimum setting of 55°F (adjustable). The discharge duct static pressure shall remain at the minimum duct static pressure set-point.
  - b. If any VAV damper remains more than 75% (adjustable) open, the supply fan discharge duct static pressure set-point shall be reset upward by 0.1 in W.C. (adj.), at a frequency of 10 minutes (adj.), until no damper is more than 75% open or the static pressure set-point has reset upward to the system maximum duct static pressure set-point or the AHU variable-frequency drive is at the maximum speed setting.

- C. The BAS shall provide the ability to automatically commission and calibrate the VAV Air System. The following tests shall be performed, at a minimum:
1. Calibration of the air valve / damper
  2. Verification of air flow through the VAV box
  3. Verification of local reheat performance for hydronic
  4. Provide the ability to initiate the auto-commissioning /auto-calibration command directly from the user interface.



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5. Provide the ability to stagger the auto-commissioning /auto-calibration sequence for groups of VAV boxes to allow the sequence to be performed during occupied hours, if necessary.
6. Provide an auto-commissioning report for the VAV Air System that shall be generated that contains the results of the auto-commissioning / auto-calibration tests. This report shall contain the following information for each VAV box in the system:
  - a. Name of VAV box
  - b. Date and time the VAV box was tested
  - c. Presence of any alarms
  - d. Space temperature and set-point
  - e. Active airflow (in CFM)
  - f. Air valve / damper position when the VAV box reaches 40% of the maximum cooling airflow set-point
  - g. Air valve / damper position when the VAV box reaches 100% of the maximum cooling airflow set-point
  - h. Discharge air temperature of the VAV box when the hydronic heat is active.

D. Optimal Start Mode

1. The BAS shall initiate the Optimal Start mode such that the VAV air handler is started and VAV boxes serving the Area are enabled prior to when the space being served by the Area is scheduled to be occupied, to allow the zone temperature to reach the pending occupied heating or cooling setpoint. The system shall wait as long as possible before starting, so that the temperature in each zone reaches the occupied setpoint just in time for scheduled occupancy. Ventilation functions shall be disabled when in Optimal Start mode.
2. The BAS shall use a self-adjusting algorithm to calculate the actual time to initiate Optimal Start for the Area based on the occupied setpoint, space temperature, historical optimal start performance data and the associated heating or cooling optimal start rate.
3. An early start limit shall be provided to prevent the Area from starting prior to 120 minutes (adj.) before scheduled occupancy.
4. The Area shall transition from Optimal Start mode to Occupied mode when the current time is equal to the scheduled start time.

E. Optimal Stop Mode

1. The BAS shall determine how early cooling or heating can be disabled for the VAV Air System so that the zone temperature is allowed to drift no more than 2 deg F from the occupied set-point, by the end of the scheduled occupancy period.  
The early stop limit is 120 minutes (adj.) The AHU supply fan be energized until the end of the scheduled occupancy period.

F. Unoccupied Mode:

1. When the air handling unit is indexed to the unoccupied mode from the air handling unit controller, downloaded from the operator workstation, the supply and exhaust fans shall stop, the outside air and exhaust air dampers shall close and the return air damper shall open. When the supply fan is off during the unoccupied mode the preheat coil control valve shall be under control of the mixed air temperature sensor and maintain a fan plenum temperature of 65 deg, F. (adj.).
2. On a call for heat during the unoccupied heating season the supply and return fans shall cycle to maintain a reduced room temperature of 65 deg. F. (adj.).

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3. On a call for cooling during the unoccupied cooling season the supply and return fans shall cycle to maintain a high limit room temperature of 85 deg. F. (adj.). When the supply fan runs during the unoccupied cooling mode the mechanical cooling shall operate and shall be controlled as described for the occupied mode.
4. During the unoccupied mode a sensor located in the waiting room shall be the input for the reduced/high limit temperature setting.
5. The air handling unit shall circulate return air only when the fans run during the unoccupied mode.
6. The unoccupied mode for either heating or cooling shall be individually activated through a BAS workstation command.
7. Warm-Up (heating season only):
  - a. When the air handling unit is indexed to the occupied mode from the air handling unit controller the supply and return fans shall start and shall circulate return air only until the return air temperature reaches 68 deg. F. (adj.).
  - b. The system shall then return to the occupied mode.

G. Safeties and Alarms

1. A low limit control located in the preheat coil discharge air shall stop the supply fan whenever the discharge air temperature falls below 35 deg. F. When the supply fan stops the return/exhaust fan shall also stop, the outside air and exhaust air dampers shall close and the return air damper shall open.
2. When the fire alarm system is in alarm the supply and return fans shall stop.
3. A high limit static pressure switch in the supply fan discharge and a low limit static pressure switch in the return/exhaust fan inlet shall stop the fans when their limits are exceeded.
4. Run/Stop Input - The ASC shall stop the unit completely when a binary input closes. This binary input shall be controlled by an external system like smoke control or fire safety. Normal operation shall be resumed when the input opens.
5. Supply Fan & Return Fan Status - The ASC shall monitor the fan outputs to determine fan status and support a positive proof fan switch. If after a minute of energizing the fan output or during normal operation the fan status switch indicates no fan operation, the ASC shall perform a shutdown and generate a Fan Failure diagnostic. The diagnostic shall be reset manually.
6. Filter Status - A normally open, operator configurable, differential pressure switch shall monitor the differential pressure across the filter when the fan is running. If during normal operation the switch closes a dirty filter alarm shall be issued.
7. Reset - All diagnostics shall be capable of being reset through the zone sensor, service tool, BAS, or by cycling power to the unit.
8. FREEZE PROTECTION - The following option requires a Capillary sensor (Freezestat) installed on the face of hydronic heating coil.
9. Fan Off Delay - After heating has being controlled off, the ASC shall keep the fan energized for an additional 30 seconds. The purpose of this action is to remove residual

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heat from the heating source

H. AHU-1E DDC Control Point List

I. The Digital Inputs and Outputs listed below are for AHU-1E.

1. Digital Outputs

- a. Supply Fan SF-1a Start/Stop
- b. Supply Fan SF-1b Start/Stop
- c. Return/Exhaust Fan REF-1a Start/Stop
- d. Return/Exhaust Fan REF-1b Start/Stop
- e. Discharge Air Isolation Damper

2. Digital Inputs

- a. Supply Fan SF-1a Status/Alarm
- b. Supply Fan SF-1b Status/Alarm
- c. Return/Exhaust Fan REF-1a Status/Alarm
- d. Return/Exhaust Fan REF-1b Status/Alarm
- e. Low Limit Device @ entering face of pre-heat coil
- f. High Limit Positive Static Pressure @ unit discharge
- g. High Limit Negative Static Pressure @ unit return/exhaust intake.
- h. Supply Duct Smoke Detector
- i. Return/Exhaust Duct Smoke Detector
- j. Return/Exhaust Air Filter Differential Pressure Switch
- k. Supply Air Filter Differential Pressure Switch

3. Analog Inputs

- a. Discharge Air Temperature
- b. Return/Exhaust Air Temperature (upstream of energy wheel)
- c. Return/Exhaust Air Temperature (downstream of energy wheel)
- d. Return/Exhaust Air Humidity (upstream of energy wheel)
- e. Outdoor Air Temperature (upstream of energy wheel)
- f. Outdoor Air Temperature (downstream of energy wheel)
- g. Outdoor Air Humidity (upstream of energy wheel)
- h. Mixed Air Temperature entering preheat coil.
- i. Preheat Coil discharge air temperature.
- j. Supply Fan SF-1a Speed (Hz)
- k. Supply Fan SF-1b Speed (Hz)
- l. Return/Exhaust Fan REF-1a Speed (Hz)
- m. Return/Exhaust Fan REF-1b Speed (Hz)
- n. Energy Wheel Rotation
- o. Building Pressure Sensors
- p. Static Pressure Sensors

4. Analog Outputs

- a. Supply Fan SF-1a VFD
- b. Supply Fan SF-1b VFD
- c. Return/Exhaust Fan REF-1a VFD

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- d. Return/Exhaust Fan REF-1b VFD
- e. Outdoor Air Damper
- f. Return Air Damper
- g. Wheel Bypass Damper (Exhaust Air)
- h. Wheel Bypass Damper (Outdoor Air)
- i. Pre-heat Coil Control Valve
- j. Chilled Water Control Valve
- k. Energy Wheel VFD
- l. Outdoor Air Flow Station
- m. Return Air Flow Station

**1.11 AIR HANDLING UNITS AHU-2B & 2C (AUDITORIUM)**

- A. Air handling unit AHU-2B and 2C are variable volume units equipped with supply fan, return fan, outside air (normally closed), relief air (normally closed) and return air (normally open) mixing dampers, preheating coil and chilled water cooling coil. The air handling unit supplies medium pressure air to VAV boxes with reheat serving the Auditorium, Stage and adjacent areas.
- B. The air handling unit shall run continuously during the occupied mode. The air handling unit supply fan and return fan shall be interlocked. When the supply fan runs the return fan shall also run.
- C. Discharge Air / Economizer Control: The air handling unit controller shall sense the discharge air temperature and control the pre-heat coil, chilled water cooling coil and mixing dampers in sequence to maintain 53 deg. F. (adj.) at the discharge of the cooling coil as follows:
  - 1. The outside air, return air and exhaust air dampers shall modulate to maintain the discharge air temperature. A mixed air sensor shall maintain a low limit mixed air temperature of 40 deg. F.(adj.) except the outside air damper shall remain at its minimum position on a call for less outside air.
  - 2. On a call for heating, when the outside air damper is at its minimum position, the preheat coil control valve shall modulate to maintain the discharge air temperature.
  - 3. On a call for cooling the outside air, return air and exhaust dampers shall modulate to increase the outside air intake. When the outside air damper is at the 100% open position and the discharge air temperature continues to rise the chilled water control valve shall modulate open. When mechanical cooling is operating it shall be controlled from discharge air temperature. When the outside air temperature is above 55 deg. F. (adj.) the outside air damper shall return to its minimum position. Mechanical cooling shall be locked out below 40 deg. F. (adj.) outside air temperature and when the supply fan is off.
- D. The air handling unit controller shall sense the return air relative humidity and trend return air humidity for monitoring purposes only.
- E. Static pressure control: The air handling unit controller shall sense the supply air static pressure at a point 2/3 down the supply air duct and maintain a constant supply air static pressure by controlling the supply fan VFD. A second supply air static pressure sensor shall be located at the end of the longest duct run from the air handling unit. If the static pressure at the end of the duct run falls below a predetermined set point the end of duct run transmitter shall override to control the supply air static pressure. The control point of the end of duct run sensor shall be determined during system balancing. The set point shall be the critical low point where the terminal units can operate. On supply fan start-up the VFD shall begin controlling at minimum flow.

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- F. Building Pressure Control: The air handling unit controller shall maintain positive building static pressure by controlling the return fan speed to track the supply fan speed and maintain a fixed offset of outdoor airflow as required to keep the space under positive pressure. On return fan start-up the VFD shall begin controlling at minimum flow.
- G. Demand Control Ventilation - CO2 Control:
  - 1. There shall be CO2 sensor installed in critical zones as indicated on drawings. When the CO2 level in a specific zone rises above the CO2 set-point (adjustable), the DDC controller will override the mixed air control and modulate the outdoor air dampers open until the CO2 level in that particular zone drops below the CO2 set-point (adjustable).
- H. Unoccupied Mode:
  - 1. When the air handling unit is indexed to the unoccupied mode from the air handling unit controller, downloaded from the operator workstation, the supply and exhaust fans shall stop, the outside air and exhaust air dampers shall close and the return air damper shall open. When the supply fan is off during the unoccupied mode the preheat coil control valve shall be under control of the mixed air temperature sensor and maintain a fan plenum temperature of 65 deg. F. (adj.).
  - 2. On a call for heat during the unoccupied heating season the supply and return fans shall cycle to maintain a reduced room temperature of 65 deg. F. (adj.).
  - 3. On a call for cooling during the unoccupied cooling season the supply and return fans shall cycle to maintain a high limit room temperature of 85 deg. F. (adj.). When the supply fan runs during the unoccupied cooling mode the mechanical cooling shall operate and shall be controlled as described for the occupied mode.
  - 4. During the unoccupied mode a sensor located in the waiting room shall be the input for the reduced/high limit temperature setting.
  - 5. The air handling unit shall circulate return air only when the fans run during the unoccupied mode.
  - 6. The unoccupied mode for either heating or cooling shall be individually activated through a BAS workstation command.
  - 7. Warm-Up (heating season only):
    - a. When the air handling unit is indexed to the occupied mode from the air handling unit controller the supply and return fans shall start and shall circulate return air only until the return air temperature reaches 68 deg. F. (adj.).
    - b. The system shall then return to the occupied mode.
- I. Safety Control:
  - 1. A low limit control located in the preheat coil discharge air shall stop the supply fan whenever the discharge air temperature falls below 35 deg. F. When the supply fan stops the return fan shall also stop, the outside air and exhaust air dampers shall close and the return air damper shall open.
  - 2. A high limit static pressure switch in the supply fan discharge and a low limit static pressure switch in the return fan inlet shall stop the fans when their limits are exceeded.
  - 3. When the fire alarm system is in alarm the supply and return fans shall stop.
- J. AHU-2B & 2C DDC Control Point List
  - 1. Digital Outputs
    - a. Supply Fan Start/Stop

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- b. Return Fan Start/Stop

2. Digital Inputs

- a. Supply Fan Status/Alarm
- b. Return Fan Status
- c. Low Limit Device
- d. Pre Filter Differential Pressure Switch
- e. Low Limit Static Pressure Switch
- f. High Limit Static Pressure Switch
- g. Supply Air Duct Smoke Detector Status
- h. Return Air Duct Smoke Detector Status

3. Analog Inputs

- a. Supply Fan VFD Feedback (Hz)
- b. Return Fan VFD Feedback (Hz)
- c. AHU Supply Air Temperature
- d. Preheat Coil Discharge Air Temperature
- e. Return Air Temperature
- f. Return Air Humidity
- g. Outdoor Air Temperature (may be global)
- h. Outdoor Air Humidity (may be global)
- i. Supply Air Static Pressure
- j. Supply Fan Speed (Hz)
- k. Mixed Air Temperature

4. Analog Outputs

- a. Supply Fan VFD Control
- b. Return Fan VFD Control
- c. Chilled Water Control Valve
- d. Preheat Coil Control Valve
- e. Return Air Damper
- f. Outdoor Air Damper
- g. Relief Air Damper
- h. Outdoor Airflow Station
- i. Return Airflow Station

**1.12 AIR HANDLING UNITS AHU-3D & 3E (INDUSTRIAL SHOPS)**

- A. Air handling unit AHU-3D & 3E is a variable volume system with supply fan, outside air (normally closed) and return air (normally open) mixing dampers, reheat coil and chilled water cooling coil. The air handling unit supplies low pressure supply air to the Industrial Shop Classrooms.
- B. The air handling unit shall run continuously during the occupied mode.
- C. Single Zone VAV Control – During cooling mode the AHU shall provide single zone VAV operation. When space temperature set-point is satisfied the AHU supply fan shall modulate fan speed to approximately 67% of design airflow, or manufacturers AHU minimum airflow (whichever is lower). This shall be considered the minimum cooling airflow.

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1. As demand for cooling increases the AHU shall maintain constant discharge air temperature (53 deg F) and increase supply airflow to satisfy space temperature.
  2. When operating at cooling minimum airflow the reheat coil shall be off unless space temperature drops below set-point. The reheat coil shall only operate to maintain space temperature when AHU is operating at minimum airflow. Above cooling minimum airflow it is intended that a reduction in supply airflow will provide for temperature control.
  3. During heating mode the AHU shall initially provide heat at the cooling minimum airflow, with a discharge air limit of 95 deg F. As the demand for heat increases the supply fan shall increase speed until space temperature set-point is satisfied. At no time shall the discharge air exceed 95 deg F.
- D. Discharge Air / Economizer Control: The air handling unit controller shall sense the discharge air temperature and control the pre-heat coil, chilled water cooling coil and mixing dampers in sequence to maintain 53 deg. F. (adj.) at the discharge of the cooling coil as follows:
1. The outside air and return air dampers shall modulate to maintain the discharge air temperature. A mixed air sensor shall maintain a low limit mixed air temperature of 40 deg. F.(adj.) except the outside air damper shall remain at its minimum position on a call for less outside air.
  2. On a call for heating, when the outside air damper is at its minimum position, the preheat coil control valve shall modulate to maintain the discharge air temperature.
  3. On a call for cooling the outside air, return air and exhaust dampers shall modulate to increase the outside air intake. When the outside air damper is at the 100% open position and the discharge air temperature continues to rise the chilled water control valve shall modulate open. When mechanical cooling is operating it shall be controlled from discharge air temperature. When the outside air temperature is above 55 deg. F. (adj.) the outside air damper shall return to its minimum position. Mechanical cooling shall be locked out below 40 deg. F. (adj.) outside air temperature and when the supply fan is off.
- E. Space Temperature Control: The air handling unit controller shall modulate the air-handling unit reheat coil to maintain space temperature in the Industrial Shops. The air handling unit controller shall sense the return air relative humidity and trend return air humidity for monitoring purposes only.
- F. Building Pressure Control: Barometric Relief. No DDC control.
- G. Demand Control Ventilation - CO2 Control:
1. There shall be CO2 sensor installed in critical zones as indicated on drawings. When the CO2 level in a specific zone rises above the CO2 set-point (adjustable), the DDC controller will override the mixed air control and modulate the outdoor air dampers open until the CO2 level in that particular zone drops below the CO2 set-point (adjustable).
- H. Unoccupied Mode:
1. When the air handling unit is indexed to the unoccupied mode from the air handling unit controller, downloaded from the operator workstation, the supply and exhaust fans shall stop, the outside air and exhaust air dampers shall close and the return air damper shall open. When the supply fan is off during the unoccupied mode the preheat coil control valve shall be under control of the mixed air temperature sensor and maintain a fan plenum temperature of 65 deg, F. (adj.).
  2. On a call for heat during the unoccupied heating season the supply and return fans shall cycle to maintain a reduced room temperature of 65 deg. F. (adj.).

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3. On a call for cooling during the unoccupied cooling season the supply and return fans shall cycle to maintain a high limit room temperature of 85 deg. F. (adj.). When the supply fan runs during the unoccupied cooling mode the mechanical cooling shall operate and shall be controlled as described for the occupied mode.
  4. During the unoccupied mode a sensor located in the waiting room shall be the input for the reduced/high limit temperature setting.
  5. The air handling unit shall circulate return air only when the fans run during the unoccupied mode.
  6. The unoccupied mode for either heating or cooling shall be individually activated through a BAS workstation command.
  7. Warm-Up (heating season only):
    - a. When the air handling unit is indexed to the occupied mode from the air handling unit controller the supply and return fans shall start and shall circulate return air only until the return air temperature reaches 68 deg. F. (adj.).
    - b. The system shall then return to the occupied mode.
- I. Safety Control:
1. When mixed air temperature drops below 35 deg F the existing hot water recirc pump shall be commanded on to maintain full hot water flow through the preheat coil at all times.
    - a. When the recirc pump is activated the 3-way mixing valve shall modulate to maintain space temperature with the pump providing full flow to the coil.
    - b. If the discharge air temperatures drops below 35 F with the pump status on, the supply fan shall stop, the outside air damper shall close and the return air damper shall open.
    - c. A flow switch shall be located in the return pipe to the preheat coil and shall sense hot water flow. Upon a loss of flow the hot water re-circulating pump shall be commanded on and an alarm shall be generated indicating loss of flow.
    - d. If the hot water re-circulating pump is commanded on and the flow switch does not detect water flow the supply fan shall stop and an alarm shall be generated indicated pump failure.
  2. When the fire alarm system is in alarm the supply fan shall stop.
- J. AHU-3D & 3E DDC Control Point List
5. Digital Outputs
    - d. Supply Fan Start/Stop
    - e. Hot Water Recirculating Pump Start/Stop
  6. Digital Inputs
    - h. Supply Fan Status/Alarm
    - i. Hot Water Recirculating Pump Status
    - j. Low Limit Device
    - k. Pre Filter Differential Pressure Switch
    - l. Preheat Coil Flow Switch
    - m. Supply Air Duct Smoke Detector Status
    - n. Return Air Duct Smoke Detector Status
  7. Analog Inputs



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- g. Supply Fan VFD Feedback (Hz)
  - h. Return Fan VFD Feedback (Hz)
  - i. AHU Supply Air Temperature
  - j. Preheat Coil Discharge Air Temperature
  - k. Return Air Temperature
  - l. Return Air Humidity
  - m. Outdoor Air Temperature (may be global)
  - n. Outdoor Air Humidity (may be global)
  - o. Supply Fan Speed (Hz)
  - p. Mixed Air Temperature
  - q. Space CO2 Sensor
  - r. Space Temperature Sensor
8. Analog Outputs
- a. Supply Fan VFD Control
  - b. Return Fan VFD Control
  - c. Chilled Water Control Valve
  - d. Preheat Coil Control Valve
  - e. Return Air Damper
  - f. Outdoor Air Damper

**1.13 ROOF TOP UNIT RTU-1H**

- A. Roof Top Units RTU-1H shall come furnished with on-board microprocessor-based controls and a BACnet communications card to allow interface with the building automation system. All available control points, data and information from the RTU control system shall be uploaded to the building automation system and populated onto graphic screens to allow maintenance operators to observe unit performance adjust schedules and make set-point adjustments of discharge air temperature.
- B. Temperature control contractor shall establish initial occupied and unoccupied schedules of operation for each RTU and provide programming adjustments to RTU sequence of operation to allow for discharge air reset and static pressure reset.

**1.14 VAV TERMINAL UNITS WITH HOT WATER REHEAT**

- A. The VAV terminal units shall be controlled by DDC controllers with electronic volume damper actuators and electric reheat coil control valve actuators. All components shall be provided by the Temperature Control Subcontractor. The DDC controller and electric volume damper actuator shall be shipped to the VAV terminal unit manufacturer for factory mounting, wiring and testing.
- B. The VAV controller shall sense room temperature and VAV box air flow and control as follows:
  - 1. On a call for cooling the controller shall modulate the volume damper from minimum to maximum air flow to maintain the required room temperature.
  - 2. On a call for neither cooling nor heating the controller shall modulate the volume damper to minimum flow.

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3. On a call for heating the reheat coil control valve shall modulate to maintain room temperature with the VAV terminal unit volume damper at minimum flow. After the reheat coil control valve is full open and further heat is required the volume damper shall modulate open to 75% flow.
- C. Coordination of work by the Temperature Control Subcontractor and the Air Balance Contractor shall be provided to assure accurate settings of all VAV terminal units maximum and minimum CFM.

**1.15 EXISTING UNIT VENTILATOR CONTROL SEQUENCE**

- A. The control sequence for existing unit ventilators shall be modified to match the sequence of operation for the new unit ventilators.
- B. Temperature control contractor shall furnish new chilled water control valve for installation by mechanical contractor.
- C. Modify existing DDC controller programming to provide cooling with the new chilled water valve.
- D. Verify existing control program matches the sequence of operation for new unit ventilators.

**1.16 NEW UNIT VENTILATOR CONTROL SEQUENCES**

- A. Unit Ventilator Control: Space temperature sensor with set point adjustment (which can be limited by the district maintenance staff to +/- desired degrees from set point), Space CO2 sensor [the space temperature and CO2 sensor should be in one housing as a combined unit], discharge air temperature sensor, low limit safety, heating/cooling 4-pipe control valve, fan enable, fan status and open protocol direct digital controller. All control points will be displayed on the BAS including set points.
  1. Warm-up Cycle: Open heating-water supply control valve, close outside-air dampers, and open return-air damper.
  2. Occupied Damper Operations: Move outside-air and return-air dampers to minimum outside-air position. This minimum position should initially be 20% (adj.), but is subject to increase above this point as determined by the room Co2 sensed value. If the sensed Co2 value exceeds set point the outside dampers will be moved from the initial minimum value and increased as needed to bring the Co2 levels back within acceptable range. Room temperature sensor modulates outside-air and return-air dampers when fresh air cooling is available and required. Airstream sensor overrides room temperature sensor to control valves and dampers to prevent discharge air from dropping below a minimum set point.
  3. Unoccupied Damper Operations: Dampers remain closed. Optional night purge cycle can be used to cool the space during a night cycle cooling call if desired using the dampers to cool the space when outside temperatures are acceptable.

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4. Room temperature sensor modulates heating hot water and chilled water valves as required to maintain space set point. When outside air is determined to be acceptable for cooling the dampers will be used to cool the space.
  5. During heating mode the heating hot water valve shall be 100% open and face and bypass dampers shall modulate to maintain space temperature.
  6. During occupied periods the fan runs continuously and the speed is automatically controlled in sequence with the heating and cooling requirements as subject to minimum speeds set by the air balancing contractor for both heating and cooling. During unoccupied periods the fan is cycled as needed along with heating and cooling to maintain night cycle settings.
  7. Low limit safety will stop fan, close outside dampers and open heating valve to protect unit. In addition, an alarm will be sent to the BAS.
- B. DDC Control Point List:
1. Digital Outputs
    - a. Supply Fan Start-Stop (On/Off)
  2. Digital Inputs
    - a. Low Limit
    - b. Supply Fan Status
  3. Analog Inputs
    - a. CO2 Sensor
    - b. Discharge Air Temperature
    - c. Mixed Air Temperature
    - d. Outdoor Air Temperature
    - e. Return Air Temperature
    - f. Return Air Humidity
    - g. Space Temperature
  4. Analog Outputs
    - a. Supply Fan Speed (ECM Motor)
    - b. Outdoor/Return Air Dampers
    - c. Heating Control Valve
    - d. Cooling Control Valve
    - e. Face and Bypass Dampers

#### **1.17 FAN COIL UNITS**

- A. Fan coil units shall be controlled from a local wall mounted DDC sensor which shall modulate the fan coil unit chilled water coil control valve and/or reheat coil control valve to maintain room temperature. The fan coil unit shall be programmed to prevent simultaneous heating and cooling.
- B. Unoccupied Mode: Shut the fan off and close control valve.

#### **1.18 CABINET UNIT HEATERS & UNIT HEATERS**

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- A. All cabinet unit heaters are constant volume unit, with 2-pipe heating coil. On a call for heat the supply fan shall sequence on and operate continuously.
- B. Provide DDC controls to cycle supply fan on & off to maintain space temperature.
- C. When space temperature is satisfied the supply fan shall shut off.
- D. Each cabinet unit heater shall include a two-position control valve to prevent chilled water flow through cabinet heater when the 2-pipe system is in cooling operation.

**1.19 HOT WATER CONVECTORS**

- A. Provide DDC controls to modulate two-way control valve to maintain space temperature.
- B. During cooling mode the control valve shall be closed and lock out of operation.

**1.20 FINNED TUBE RADIATION**

- A. Provide DDC controls to modulate two-way control valve to maintain space temperature.
- B. During cooling mode the control valve shall be closed and lock out of operation.

**1.21 EMERGENCY VENTILATION EXHAUST FAN EF-P200**

- A. Exhaust fan EF-P200 serves dual purposes, as a general ventilation fan for the penthouse for and also as emergency ventilation in the event of refrigerant leak.
- B. When the refrigerant monitor system goes into alarm, the exhaust fan shall be overridden into the on position. In addition to the control described above, the exhaust fan shall have a manual emergency "break glass" type switch which provides a hard-wired 1-hr override into emergency ventilation mode. Emergency switch shall be located directly outside mechanical room door.

**1.22 REFRIGERANT MONITORING SYSTEM**

- A. Temperature control contractor shall furnish and install a MSA Chillgard LS (or equal) refrigerant monitoring/alarm system capable of detecting either R-134a or R410a with both audible and visible alarms. Install at location shown in new penthouse on heating plans.

**1.23 EXHAUST FANS:** Exhaust fans are constant volume roof mounted centrifugal fans. The fans shall be controlled through the BAS as follows:

- 1. Exhaust Fan Control: Each exhaust fan identified above shall operate based on an occupied/unoccupied schedule provided by BAS. Provide start/stop and status control points.

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- a. Occupied Mode: Exhaust fan shall run continuously during occupied mode:
  - b. Unoccupied Mode: Exhaust fan shall be commanded off.
2. Backdraft damper control: Each exhaust fan shall be provided with a motor operated backdraft damper that is interlocked with the operation of the exhaust fan.
- a. When the fan is off the back draft damper shall be closed.
  - b. When the fan is on the back draft damper shall be open.

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

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

**END OF SECTION 23 0993.11.51**



**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.

**1.2 SUMMARY**

- A. Section includes pipe and fitting materials and joining methods for the following:
  - 1. Copper tube and fittings.
  - 2. Steel pipe and fittings.
  - 3. Joining materials.
  - 4. Transition fittings.
  - 5. Dielectric fittings.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Pipe.
  - 2. Fittings.
  - 3. Joining materials.
  - 4. Bypass chemical feeder.

**1.4 QUALITY ASSURANCE**

- A. Installer Qualifications:
  - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

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1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: 100 psig at 200 deg F.
  2. Chilled-Water Piping: 150 psig at 73 deg F.
  3. Dual-Temperature Heating and Cooling Water Piping: 100 psig at 200 deg F.
  4. Makeup-Water Piping: 80 psig at 73 deg F.
  5. Condensate-Drain Piping: 150 deg F.
  6. Blowdown-Drain Piping: 180 deg F.
  7. Air-Vent Piping: 180 deg F.
  8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

### **2.2 COPPER TUBE AND FITTINGS**

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
1. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
  2. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, pre-lubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.
- E. Copper or Bronze Pressure-Seal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Viega Pro-Press System
  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 deg F.



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- F. Wrought-Copper Unions: ASME B16.22.

## **2.3 STEEL PIPE AND FITTINGS**

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1. Material Group: 1.1.
  - 2. End Connections: Butt welding.
  - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
  - 1. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
  - 2. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

## **2.4 JOINING MATERIALS**

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

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- a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
  - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

## **2.5 TRANSITION FITTINGS**

- A. Plastic-to-Metal Transition Fittings:
  - 1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- B. Plastic-to-Metal Transition Unions:
  - 1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

## **2.6 DIELECTRIC FITTINGS**

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
  - 1. Description:
    - a. Standard: ASSE 1079.
    - b. Pressure Rating: 150 psig minimum at 210 deg F.
    - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
  - 1. Description:
    - a. Standard: ASSE 1079.
    - b. Factory-fabricated, bolted, companion-flange assembly.
    - c. Pressure Rating: 150 psig minimum at 210 deg F.
    - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
  - 1. Description:

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- a. Nonconducting materials for field assembly of companion flanges.
  - b. Pressure Rating: 150 psig minimum at 210 deg F.
  - c. Gasket: Neoprene or phenolic.
  - d. Bolt Sleeves: Phenolic or polyethylene.
  - e. Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples:
- 1. Description:
    - a. Standard: IAPMO PS 66.
    - b. Electroplated steel nipple, complying with ASTM F 1545.
    - c. Pressure Rating: 150 psig minimum at 210 deg F.
    - d. End Connections: Male threaded or grooved.
    - e. Lining: Inert and noncorrosive, propylene.

### **PART 3 - EXECUTION**

#### **3.1 PIPING APPLICATIONS**

- A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
- 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
  - 2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
- 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
  - 2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
  - 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Hot-water heating piping installed belowground and within slabs shall be either of the following:
- 1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
- D. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
- 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
  - 2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- E. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

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1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
  2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
  3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- F. Chilled-water piping installed belowground and within slabs shall be either of the following:
1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
- G. Makeup-water piping installed aboveground shall be either of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- H. Condensate-Drain Piping: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- I. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- J. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
  2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- K. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

### **3.2 PIPING INSTALLATIONS**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.

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- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
  - 1. Section 230523.12 "Ball Valves for HVAC Piping."
  - 2. Section 230523.13 "Butterfly Valves for HVAC Piping."
  - 3. Section 230523.14 "Check Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

### **3.3 DIELECTRIC FITTING INSTALLATION**

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

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- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

### **3.4 HANGERS AND SUPPORTS**

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
  - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
  - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
  - 4. Spring hangers to support vertical runs.
  - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
  - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 7 feet.
  - 2. NPS 1: Maximum span, 7 feet.
  - 3. NPS 1-1/2: Maximum span, 9 feet.
  - 4. NPS 2: Maximum span, 10 feet.
  - 5. NPS 2-1/2: Maximum span, 11 feet.
  - 6. NPS 3 and Larger: Maximum span, 12 feet.
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
  - 4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

- G. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

### **3.5 PIPE JOINT CONSTRUCTION**

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. 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.
- E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- H. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

### **3.6 TERMINAL EQUIPMENT CONNECTIONS**

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

### **3.7 CHEMICAL TREATMENT**

- A. Comply with requirements in Section 232513 "Water Treatment for Closed-Loop Hydronic Systems".
- B. Install side-stream filters to provide service as chemical feeders in each hydronic system where indicated.
  - 1. Install in upright position with top of funnel not more than 48 inches above the floor.
  - 2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
  - 3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

### **3.8 FIELD QUALITY CONTROL**

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
  - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
  - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
  - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
  - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
  - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
  - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
  - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
  - 3. Isolate expansion tanks and determine that hydronic system is full of water.
  - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum



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- yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
  6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
  2. Inspect pumps for proper rotation.
  3. Set makeup pressure-reducing valves for required system pressure.
  4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
  5. Set temperature controls so all coils are calling for full flow.
  6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
  7. Verify lubrication of motors and bearings.

**END OF SECTION 23 2113**



**SECTION 23 2116**

**HYDRONIC PIPING SPECIALTIES**

**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. Hydronic specialty valves.
  - 2. Air-control devices.
  - 3. Strainers.
  - 4. Connectors.
- B. Related Requirements:
  - 1. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
  - 2. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
  - 3. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
  - 4. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product:
  - 1. Include construction details and material descriptions for hydronic piping specialties.
  - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
  - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

## **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

## **1.6 QUALITY ASSURANCE**

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

## **PART 2 - PRODUCTS**

### **2.1 HYDRONIC SPECIALTY VALVES**

- A. 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; a Xylem brand.
    - c. Flow Design, Inc.
    - d. Griswold Controls.
    - e. HCI; Hydronics Components Inc.
    - f. Nexus Valve, Inc.
    - g. NIBCO 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 Gage Connections: Integral seals for portable differential pressure meter.
  - 8. Handle Style: Lever, with memory stop to retain set position.
  - 9. CWP Rating: Minimum 125 psig.
  - 10. Maximum Operating Temperature: 250 deg F.
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- a. Armstrong Pumps, Inc.
    - b. Bell & Gossett; a Xylem brand.
    - c. Flow Design, Inc.
    - d. Griswold Controls.
    - e. HCI; Hydronics Components Inc.
    - f. Nexus Valve, Inc.
    - g. NIBCO INC.
  2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
  3. Ball: Brass or stainless steel.
  4. Stem Seals: EPDM O-rings.
  5. Disc: Glass and carbon-filled PTFE.
  6. Seat: PTFE.
  7. End Connections: Flanged or grooved.
  8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
  9. Handle Style: Lever, with memory stop to retain set position.
  10. CWP Rating: Minimum 125 psig.
  11. Maximum Operating Temperature: 250 deg F.
- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AMTROL, Inc.
    - b. Apollo Flow Controls; Conbraco Industries, Inc.
    - c. Armstrong Pumps, Inc.
    - d. Bell & Gossett; a Xylem brand.
  2. Body: Bronze or brass.
  3. Disc: Glass and carbon-filled PTFE.
  4. Seat: Brass.
  5. Stem Seals: EPDM O-rings.
  6. Diaphragm: EPT.
  7. Low inlet-pressure check valve.
  8. Inlet Strainer: stainless steel, removable without system shutdown.
  9. Valve Seat and Stem: Noncorrosive.
  10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- D. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AMTROL, Inc.
    - b. Apollo Flow Controls; Conbraco Industries, Inc.
    - c. Armstrong Pumps, Inc.
    - d. Bell & Gossett; a Xylem brand.

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2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Caleffi.
  - b. Flow Design, Inc.
  - c. Griswold Controls.
  - d. HCI; Hydronics Components Inc.
  - e. Nexus Valve, Inc.
  - f. NIBCO INC.
2. Body: Brass or ferrous metal.
3. Flow Control Assembly, provide either of the following:
  - a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
  - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

## 2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. AMTROL, Inc.
  - b. Apollo Flow Controls; Conbraco Industries, Inc.

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- c. Armstrong Pumps, Inc.
    - d. Bell & Gossett; a Xylem brand.
    - e. HCI; Hydronics Components Inc.
    - f. Nexus Valve, Inc.
  2. Body: Bronze.
  3. Internal Parts: Nonferrous.
  4. Operator: Screwdriver or thumbscrew.
  5. Inlet Connection: NPS 1/2.
  6. Discharge Connection: NPS 1/8.
  7. CWP Rating: 150 psig.
  8. Maximum Operating Temperature: 225 deg F.
- B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AMTROL, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett; a Xylem brand.
    - d. Nexus Valve, Inc.
    - e. NuTech Hydronic Specialty Products.
  2. Body: Bronze or cast iron.
  3. Internal Parts: Nonferrous.
  4. Operator: Noncorrosive metal float.
  5. Inlet Connection: NPS 1/2.
  6. Discharge Connection: NPS 1/4.
  7. CWP Rating: 150 psig.
  8. Maximum Operating Temperature: 240 deg F.
- C. Bladder-Type ASME Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. AMTROL, Inc.
    - b. Armstrong Pumps, Inc.
    - c. Bell & Gossett; a Xylem brand.
    - d. American Wheatley
  2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
  4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- D. Coalescing-Type Air and Dirt Separators:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Spiro-Therm – Spirovent Air/Dirt Separator
  - b. Bell & Gossett
  - c. Armstrong
  - d. Wessels
2. Tank: Two-piece cast iron body with an integral copper core tube with continuously wound copper wire medium constructed to suppress turbulence and maximize air separation.
3. Maximum Working Pressure: Up to 175 psig.
4. ASME Rated.
5. Maximum Operating Temperature: Up to 300 deg F.

## **2.3 STRAINERS**

### **A. Y-Pattern Strainers:**

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 60-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

### **B. Basket Strainers:**

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

### **C. T-Pattern Strainers:**

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.



## **2.4 CONNECTORS**

- A. Spherical, Rubber, Flexible Connectors:
  - 1. Body: Fiber-reinforced rubber body.
  - 2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
  - 3. Performance: Capable of misalignment.
  - 4. CWP Rating: 150 psig.
  - 5. Maximum Operating Temperature: 250 deg F.

## **PART 3 - EXECUTION**

### **3.1 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 in the return pipe of each heating or cooling terminal.
- C. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

### **3.2 HYDRONIC SPECIALTIES INSTALLATION**

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
  - 1. Install tank fittings that are shipped loose.
  - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

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- F. Install expansion tanks on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

**END OF SECTION 23 2116**

**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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Close-coupled, in-line centrifugal pumps.
  - 2. Separately coupled, horizontally mounted, in-line centrifugal pumps.
  - 3. Separately coupled, base-mounted, end-suction centrifugal pumps.

**1.3 DEFINITIONS**

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
  - 1. Show pump layout and connections.
  - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
  - 3. Include diagrams for power, signal, and control wiring.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

## **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Mechanical Seals: One mechanical seal(s) for each pump.

## **PART 2 - PRODUCTS**

### **2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. Aurora Pump; Pentair Ltd.
  - 3. ITT Corporation.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
  - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
  - 3. Pump Shaft: Stainless steel.
  - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
  - 5. Pump Bearings: Oil lubricated; bronze-journal or thrust type.
- D. Motor: Single speed and rigidly mounted to pump casing.
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    - a. Enclosure: Totally enclosed, fan cooled.
    - b. Enclosure Materials: Cast iron.
    - c. Motor Bearings: Grease-lubricated ball bearings.

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- d. Efficiency: Premium efficient.
- e. NEMA Design: B.
- f. Service Factor: 1.15.

## 2.2 SEPARATELY COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armstrong Pumps, Inc.
  - 2. Aurora Pump; Pentair Ltd.
  - 3. ITT Corporation.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
  - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
  - 3. Pump Shaft: Stainless steel.
  - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
  - 5. Pump Bearings: Oil lubricated; bronze-journal or thrust type.
- D. Shaft Coupling: Molded-rubber insert with interlocking spider capable of absorbing vibration.
- E. Motor: Single speed and resiliently mounted to pump casing.
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    - a. Enclosure: Totally enclosed, fan cooled.
    - b. Enclosure Materials: Cast iron.
    - c. Motor Bearings: Grease-lubricated ball bearings.
    - d. Efficiency: Premium efficient.
    - e. NEMA Design: B.
    - f. Service Factor: 1.15.

### **2.3 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; Pentair Ltd.
  - 3. ITT Corporation.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- C. Pump Construction:
  - 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage 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: Stainless steel.
  - 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.
  - 5. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    - a. Enclosure: Totally enclosed, fan cooled.

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- b. Enclosure Materials: Cast iron.
- c. Motor Bearings: Grease-lubricated ball bearings.
- d. Efficiency: Premium efficient.
- e. NEMA Design: B.
- f. Service Factor: 1.15.

## **2.4 AUTOMATIC CONDENSATE PUMP UNITS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Beckett Corporation.
  - 2. Franklin Electric Co.
  - 3. Hartell Pumps; Milton Roy.
- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug.

## **2.5 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 gage ports with integral check valve and orifice for flow measurement.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

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- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PUMP INSTALLATION**

- A. Comply with HI 1.4 and HI 2.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- E. Equipment Mounting:
  - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.

### **3.3 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.

### **3.4 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.



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- D. Install triple-duty valve on discharge side of pumps.
- E. Install suction diffuser and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.
- I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.5 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Check piping connections for tightness.
  - 3. Clean strainers on suction piping.
  - 4. Perform the following startup checks for each pump before starting:
    - a. Verify bearing lubrication.
    - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    - c. Verify that pump is rotating in the correct direction.
  - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
  - 6. Start motor.
  - 7. Open discharge valve slowly.

### **3.6 DEMONSTRATION**

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

**END OF SECTION 23 2123**



## **SECTION 23 2213**

### **STEAM AND CONDENSATE HEATING 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 pipe and fittings for LP steam and condensate piping:
- B. Related Requirements:
  - 1. Section 232216 "Steam and Condensate Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate piping.

##### **1.3 QUALITY ASSURANCE**

- A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding: Qualify procedures and operators according to the following:
  - 1. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

#### **PART 2 - PRODUCTS**

##### **2.1 STEEL PIPE AND FITTINGS**

- A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.
- C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.
- E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1. Material Group: 1.1.
  - 2. End Connections: Butt welding.
  - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

## **2.2 JOINING MATERIALS**

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

## **PART 3 - EXECUTION**

### **3.1 LP STEAM PIPING APPLICATIONS**

- A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- C. Condensate piping above grade, NPS 2 and smaller, shall be either of the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- D. Condensate piping above grade, NPS 2-1/2 and larger, shall be either of the following:
  1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

### **3.2 ANCILLARY PIPING APPLICATIONS**

- A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- B. Vacuum-Breaker Piping: Outlet, same as service where installed.
- C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

### **3.3 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

- L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
- M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
- O. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install shutoff valve immediately upstream of each dielectric fitting.
- R. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- S. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- T. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

### **3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION**

- A. Comply with requirements in Section 232216 "Steam and Condensate Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

### **3.5 HANGERS AND SUPPORTS**

- A. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
  - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
  - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
  - 4. Spring hangers to support vertical runs.
- B. Install hangers for steel steam supply piping with the following maximum spacing:
  - 1. NPS 3/4: Maximum span, 9 feet.
  - 2. NPS 1: Maximum span, 9 feet.
  - 3. NPS 1-1/2: Maximum span, 12 feet.
  - 4. NPS 2: Maximum span, 13 feet.
  - 5. NPS 2-1/2: Maximum span, 14 feet.
  - 6. NPS 3 and Larger: Maximum span, 15 feet.

- C. Install hangers for steel steam condensate piping with the following maximum spacing:
  - 1. NPS 3/4: Maximum span, 7 feet.
  - 2. NPS 1: Maximum span, 7 feet.
  - 3. NPS 1-1/2: Maximum span, 9 feet.
  - 4. NPS 2: Maximum span, 10 feet.
  - 5. NPS 2-1/2: Maximum span, 11 feet.
  - 6. NPS 3 and Larger: Maximum span, 12 feet
- D. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

### **3.6 PIPE JOINT CONSTRUCTION**

- A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

### **3.7 TERMINAL EQUIPMENT CONNECTIONS**

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install traps and control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install vacuum breakers downstream from control valve, close to coil inlet connection.
- E. Install a drip leg at coil outlet.

### **3.8 FIELD QUALITY CONTROL**

- A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:
  - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
  - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
  - 3. Flush system with clean water. Clean strainers.
  - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
  - 2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
  - 3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
- D. Prepare test and inspection reports.

**END OF SECTION 23 2213**



## **SECTION 23 2216**

### **STEAM AND CONDENSATE PIPING SPECIALTIES**

#### **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 the following piping specialties for LP steam and condensate piping:
  - 1. Strainers.
  - 2. Steam traps.
  - 3. Thermostatic air vents and vacuum breakers.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Steam trap.
  - 2. Air vent and vacuum breaker.

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

##### **1.5 QUALITY ASSURANCE**

- A. Pipe Welding: Qualify procedures and operators according to the following:
  - 1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

#### **PART 2 - PRODUCTS**

##### **2.1 VALVES**

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Stop-Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. A.Y. McDonald Mfg. Co.
  - b. Cincinnati Valve Company.
  - c. Crane Co.
  - d. Jenkins Valves.
2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

## 2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

B. Basket Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 250-psig working steam pressure.

## 2.3 PRESSURE-REDUCING VALVES

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

1. Armstrong International, Inc.
2. Hoffman Specialty.
3. Leslie Controls, Inc.
4. Spence Engineering Company, Inc.
5. Spirax Sarco, Inc.

B. ASME labeled.

- C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.
- D. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.
- E. Body: Cast iron.
- F. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.
- G. Trim: Hardened stainless steel.
- H. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.
- I. Gaskets: Non-asbestos materials.

## **2.4 STEAM TRAPS**

- A. Float and Thermostatic Traps:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong International, Inc.
    - b. Barnes & Jones, Inc.
    - c. Dunham-Bush, Inc.
    - d. Hoffman Specialty.
    - e. Spirax Sarco, Inc.
    - f. Sterling.
  - 2. Body and Bolted Cap: ASTM A 126, cast iron.
  - 3. End Connections: Threaded.
  - 4. Float Mechanism: Replaceable, stainless steel.
  - 5. Head and Seat: Hardened stainless steel.
  - 6. Trap Type: Balanced pressure.
  - 7. Thermostatic Bellows: Stainless steel or monel.
  - 8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
  - 9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
  - 10. Maximum Operating Pressure: 125 psig.

## **2.5 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS**

- A. Thermostatic Air Vents:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong International, Inc.

- b. Barnes & Jones, Inc.
    - c. Dunham-Bush, Inc.
    - d. Hoffman Specialty.
    - e. Spirax Sarco, Inc.
    - f. Sterling.
  - 2. Body: Cast iron, bronze, or stainless steel.
  - 3. End Connections: Threaded.
  - 4. Float, Valve, and Seat: Stainless steel.
  - 5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
  - 6. Pressure Rating: 125 psig.
  - 7. Maximum Temperature Rating: 350 deg F.
- B. Vacuum Breakers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Armstrong International, Inc.
    - b. Dunham-Bush, Inc.
    - c. Hoffman Specialty.
    - d. Johnson Corporation (The).
    - e. Spirax Sarco, Inc.
  - 2. Body: Cast iron, bronze, or stainless steel.
  - 3. End Connections: Threaded.
  - 4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
  - 5. O-Ring Seal: EPR.
  - 6. Pressure Rating: 125 psig.
  - 7. Maximum Temperature Rating: 350 deg F.

## 2.6 FLEXIBLE CONNECTORS

- A. Stainless-Steel Bellows, Flexible Connectors:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Duraflex, Inc.
    - b. Flexicraft Industries.
    - c. Hyspan Precision Products, Inc.
    - d. Mason Industries, Inc.
    - e. Metraflex Company (The).
    - f. Twin City Hose, Inc.
  - 2. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
  - 3. End Connections: Threaded or flanged to match equipment connected.
  - 4. Performance: Capable of 3/4-inch misalignment.
  - 5. CWP Rating: 150 psig.
  - 6. Maximum Operating Temperature: 250 deg F.

## PART 3 - EXECUTION

### **3.1 VALVE APPLICATIONS**

- A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
- B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

### **3.2 PIPING INSTALLATION**

- A. Install piping to permit valve servicing.
- B. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- C. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- E. Install shutoff valve immediately upstream of each dielectric fitting.
- F. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

### **3.3 STEAM-TRAP INSTALLATION**

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

### **3.4 TERMINAL EQUIPMENT CONNECTIONS**

- A. Install traps and control valves in accessible locations close to connected equipment.
- B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

**END OF SECTION 23 2216**



**SECTION 23 2300**

**REFRIGERANT PIPING**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Refrigerant pipes and fittings.
  - 2. Refrigerant piping valves and specialties.
  - 3. Refrigerants.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
  - 1. Include pressure drop, based on manufacturer's test data, for the following:
    - a. Thermostatic expansion valves.
    - b. Solenoid valves.
    - c. Hot-gas bypass valves.
    - d. Filter dryers.
    - e. Strainers.
    - f. Pressure-regulating valves.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Welding certificates.
- B. Field quality-control reports.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

## **1.6 QUALITY ASSURANCE**

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

## **1.7 PRODUCT STORAGE AND HANDLING**

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

# **PART 2 - PRODUCTS**

## **2.1 PERFORMANCE REQUIREMENTS**

- A. Line Test Pressure for Refrigerant R-410A:
  - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
  - 2. Liquid Lines: 535 psig.

## **2.2 COPPER TUBE AND FITTINGS**

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8/A5.8M.
- E. Flexible Connectors:
  - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
  - 2. End Connections: Socket ends.
  - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
  - 4. Working Pressure Rating: Factory test at minimum 500 psig.
  - 5. Maximum Operating Temperature: 250 deg F.



## 2.3 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
  - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
  - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
  - 3. Operator: Rising stem and hand wheel.
  - 4. Seat: Nylon.
  - 5. End Connections: Socket, union, or flanged.
  - 6. Working Pressure Rating: 500 psig.
  - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
  - 1. Body and Bonnet: Forged brass or cast bronze.
  - 2. Packing: Molded stem, back seating, and replaceable under pressure.
  - 3. Operator: Rising stem.
  - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
  - 5. Seal Cap: Forged-brass or valox hex cap.
  - 6. End Connections: Socket, union, threaded, or flanged.
  - 7. Working Pressure Rating: 500 psig.
  - 8. Maximum Operating Temperature: 275 deg F.
- C. Check Valves:
  - 1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
  - 2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
  - 3. Piston: Removable polytetrafluoroethylene seat.
  - 4. Closing Spring: Stainless steel.
  - 5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
  - 6. End Connections: Socket, union, threaded, or flanged.
  - 7. Maximum Opening Pressure: 0.50 psig.
  - 8. Working Pressure Rating: 500 psig.
  - 9. Maximum Operating Temperature: 275 deg F.
- D. Service Valves:
  - 1. Body: Forged brass with brass cap including key end to remove core.
  - 2. Core: Removable ball-type check valve with stainless-steel spring.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Copper spring.
  - 5. Working Pressure Rating: 500 psig.
- E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
  - 1. Body and Bonnet: Plated steel.
  - 2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Threaded.
  - 5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
  - 6. Working Pressure Rating: 400 psig.
  - 7. Maximum Operating Temperature: 240 deg F.

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- F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
  - 1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
  - 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Seat: Polytetrafluoroethylene.
  - 4. End Connections: Threaded.
  - 5. Working Pressure Rating: 400 psig.
  - 6. Maximum Operating Temperature: 240 deg F.
- G. Thermostatic Expansion Valves: Comply with AHRI 750.
  - 1. Body, Bonnet, and Seal Cap: Forged brass or steel.
  - 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
  - 3. Packing and Gaskets: Non-asbestos.
  - 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
  - 5. Suction Temperature: 40 deg F.
  - 6. Superheat: Adjustable.
  - 7. Reverse-flow option (for heat-pump applications).
  - 8. End Connections: Socket, flare, or threaded union.
  - 9. Working Pressure Rating: 450 psig.
- H. Straight-Type Strainers:
  - 1. Body: Welded steel with corrosion-resistant coating.
  - 2. Screen: 100-mesh stainless steel.
  - 3. End Connections: Socket or flare.
  - 4. Working Pressure Rating: 500 psig.
  - 5. Maximum Operating Temperature: 275 deg F.
- I. Angle-Type Strainers:
  - 1. Body: Forged brass or cast bronze.
  - 2. Drain Plug: Brass hex plug.
  - 3. Screen: 100-mesh monel.
  - 4. End Connections: Socket or flare.
  - 5. Working Pressure Rating: 500 psig.
  - 6. Maximum Operating Temperature: 275 deg F.
- J. Moisture/Liquid Indicators:
  - 1. Body: Forged brass.
  - 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
  - 3. Indicator: Color coded to show moisture content in parts per million (ppm).
  - 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
  - 5. End Connections: Socket or flare.
  - 6. Working Pressure Rating: 500 psig.
  - 7. Maximum Operating Temperature: 240 deg F.
- K. Replaceable-Core Filter Dryers: Comply with AHRI 730.
  - 1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
  - 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
  - 3. Desiccant Media: Activated alumina or charcoal.
  - 4. End Connections: Socket.

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5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
  6. Maximum Pressure Loss: 2 psig.
  7. Working Pressure Rating: 500 psig.
  8. Maximum Operating Temperature: 240 deg F.
- L. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
  2. Comply with UL 207; listed and labeled by an NRTL.
  3. Body: Welded steel with corrosion-resistant coating.
  4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
  5. End Connections: Socket or threaded.
  6. Working Pressure Rating: 500 psig.
  7. Maximum Operating Temperature: 275 deg F.
- M. Liquid Accumulators: Comply with AHRI 495.
1. Body: Welded steel with corrosion-resistant coating.
  2. End Connections: Socket or threaded.
  3. Working Pressure Rating: 500 psig.
  4. Maximum Operating Temperature: 275 deg F.

## 2.4 REFRIGERANTS

- A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Arkema Inc.
    - b. DuPont Fluorochemicals Div.

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 2 to NPS 4: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.
- C. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 4 and Larger: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

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- D. Safety-Relief-Valve Discharge Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, Copper: Type ACR or Type L, drawn-temper or annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- E. Safety-Relief-Valve Discharge Piping for Conventional Air-Conditioning (Cooling-Only) Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.

### **3.2 VALVE AND SPECIALTY APPLICATIONS**

- A. Install diaphragm packless valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
  - 1. Install valve so diaphragm case is warmer than bulb.
  - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
  - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
  - 1. Solenoid valves.
  - 2. Thermostatic expansion valves.
  - 3. Compressor.
- J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- K. Install receivers sized to accommodate pump-down charge.
- L. Install flexible connectors at compressors.

### 3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
  - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
  - 2. Install horizontal suction lines with a uniform slope downward to compressor.

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3. Install traps and double risers to entrain oil in vertical runs.
  4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
1. Shot blast the interior of piping.
  2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
  3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
  4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

### **3.4 PIPE JOINT CONSTRUCTION**

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Braze Handbook," Chapter "Pipe and Tube."
1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
  2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

### **3.5 HANGERS AND SUPPORTS**

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.

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2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
  3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
  4. Spring hangers to support vertical runs.
  5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
  2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
  3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
  4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
  5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
  6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
  7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
  8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
  9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
  2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
  3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
  4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch.
- E. Support multifloor vertical runs at least at each floor.

### **3.6 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
  2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
  3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
    - a. Fill system with nitrogen to the required test pressure.
    - b. System shall maintain test pressure at the manifold gage throughout duration of test.
    - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

### **3.7 SYSTEM CHARGING**

- A. Charge system using the following procedures:
  - 1. Install core in filter dryers after leak test but before evacuation.
  - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
  - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
  - 4. Charge system with a new filter-dryer core in charging line.

### **3.8 ADJUSTING**

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
  - 1. Open shutoff valves in condenser water circuit.
  - 2. Verify that compressor oil level is correct.
  - 3. Open compressor suction and discharge valves.
  - 4. Open refrigerant valves except bypass valves that are used for other purposes.
  - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

**END OF SECTION 23 2300**



## **SECTION 23 2513**

### **WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

##### **1.2 SUMMARY**

- A. Section includes the following water treatment for closed-loop hydronic systems:
  - 1. Side Stream Filter Housing.
  - 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 ACTION SUBMITTALS**

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
  - 1. Bypass feeders.
  - 2. Water meters.
  - 3. Inhibitor injection timers.
  - 4. pH controllers.
  - 5. TSS controllers.
  - 6. Chemical solution tanks.
  - 7. Injection pumps.
  - 8. Chemical test equipment.
  - 9. Chemical material safety data sheets.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.
  - 1. Include plans, elevations, sections, and attachment details.

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2. Include diagrams for power, signal, and control wiring.

## **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

## **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.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Enerco Corporation.
  2. Crown Solutions Inc.
  3. Certified Laboratories.
  4. H-O-H Water Technology, Inc.
  5. Nalco; an Ecolab company.
  6. Earthwise Environmental

### **2.2 PERFORMANCE REQUIREMENTS**

- A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including hot-water heating, chilled water and dual-temperature water, shall have the following water qualities:
  1. pH: Maintain a value within 9.0 to 10.5.
  2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
  3. Boron: Maintain a value within 100 to 200 ppm.
  4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
  5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
  6. TSS: Maintain a maximum value of 10 ppm.
  7. Ammonia: Maintain a maximum value of 20 ppm.
  8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.

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9. Microbiological Limits:
- a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
  - b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
  - c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
  - d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
  - e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

## **2.3 SIDE STREAM FILTER HOUSING**

- A. Housing: 304 Stainless Steel, with corrosion-resistant exterior coating and band clamp closure at top of housing. Standard inlet and top side outlet shall be 2" MNPT. Unit shall be equipped with leg supports for floor installation, factory installed pressure gauges and drain ports.
- 1. Capacity: Minimum 10" diameter, filter housing height based on flow rate requirements.
  - 2. Minimum Working Pressure: 150 psig at 300 deg F.
- B. Filter Media:
- 1. Filters shall be sized for 10% of design flow rate (GPM) listed in pump schedule based on main system distribution pumps

## **2.4 CHEMICALS**

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

## **PART 3 - EXECUTION**

### **3.1 WATER ANALYSIS**

- A. Perform an analysis of supply water to determine quality of water available at Project site.

### **3.2 INSTALLATION**

- A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
- B. Side Stream Filters: Install in closed hydronic systems, including hot-water heating, chilled water, and dual-temperature water, and equipped with the following:
- 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
  - 2. Install water meter in makeup-water supply.

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3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
  4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
  5. Install a swing check on the inlet after the isolation valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

### **3.3 CONNECTIONS**

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.
- B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."
- C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Inspect field-assembled components and equipment installation, including piping and electrical connections.

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2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
  3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
  4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
  5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
  6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
  7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
  8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. 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.

### **3.5 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

**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.

##### **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. Sealants and gaskets.
  - 5. Hangers and supports.
- B. Related Sections:
  - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
  - 2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following products:
  - 1. Liners and adhesives.
  - 2. Sealants and gaskets.
- B. Shop Drawings:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Factory- and shop-fabricated ducts and fittings.
  - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
  - 4. Fittings.
  - 5. Reinforcement and spacing.
  - 6. Seam and joint construction.
  - 7. Penetrations through fire-rated and other partitions.
  - 8. Equipment installation based on equipment being used on Project.

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9. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
10. Hangers and supports, including methods for duct and building attachment and vibration isolation.

#### **1.4 QUALITY ASSURANCE**

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
  1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
  2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
  3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- D. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

#### **2.2 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.
  1. Construct ducts of galvanized sheet steel unless otherwise indicated.
  2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.



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2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
  3. Where specified for specific applications, all joints shall be welded.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
1. Where specified for specific applications, all joints shall be welded.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## **2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS**

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
  2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
  3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Ductmate Industries, Inc.
    - b. McGill AirFlow LLC.
    - c. SEMCO LLC.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal

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Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
  2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## **2.4 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.
  2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. 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.
- G. 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.

## **2.5 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 in accordance with UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
  - 1. Application Method: Brush on.
  - 2. Solids Content: Minimum 65 percent.
  - 3. Shore A Hardness: Minimum 20.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. VOC: Maximum 75 g/L (less water).
  - 7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
  - 8. Service: Indoor or outdoor.
  - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Solvent-Based Joint and Seam Sealant:
  - 1. Application Method: Brush on.
  - 2. Base: Synthetic rubber resin.
  - 3. Solvent: Toluene and heptane.
  - 4. Solids Content: Minimum 60 percent.
  - 5. Shore A Hardness: Minimum 60.
  - 6. Water resistant.
  - 7. Mold and mildew resistant.
  - 8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
  - 9. Service: Indoor or outdoor.
  - 10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
  - 1. General: Single-component, acid-curing, silicone, elastomeric.
  - 2. Type: S.
  - 3. Grade: NS.
  - 4. Class: 25.
  - 5. Use: O.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
  - 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
  - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

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3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

## **2.6 HANGERS AND SUPPORTS**

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
  1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
  2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
  3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

## **PART 3 - EXECUTION**

### **3.1 DUCT INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

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- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Elbows: Use long-radius elbows wherever they fit.
  - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
  - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
- N. Branch Connections: Use lateral or conical branch connections.

### **3.2 INSTALLATION OF EXPOSED DUCTWORK**

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- D. Repair or replace damaged sections and finished work that does not comply with these requirements.

### **3.3 DUCT SEALING**

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
  - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 2. Outdoor, Supply-Air Ducts: Seal Class A.
  - 3. Outdoor, Exhaust Ducts: Seal Class C.
  - 4. Outdoor, Return-Air Ducts: Seal Class C.
  - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
  - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
  - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
  - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
  - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
  - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
  - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
  - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

### **3.4 HANGER AND SUPPORT INSTALLATION**

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
  - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
  - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.

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- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

### **3.5 CONNECTIONS**

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

### **3.6 PAINTING**

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

### **3.7 STARTUP**

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

### **3.8 DUCT SCHEDULE**

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
  - 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Supply Ducts:
  - 1. Ducts Connected to Fan Coil Units, Furnaces, and Terminal Units:
    - a. Pressure Class: Positive 1-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
  - 2. Ducts Connected to Constant-Volume Air-Handling Units:

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- a. Pressure Class: Positive 2-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
  - 3. Ducts Connected to Variable-Air-Volume Air-Handling Units:
    - a. Pressure Class: Positive 3-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
- C. Return Ducts:
- 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
  - 2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
- D. Exhaust Ducts:
- 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - a. Pressure Class: Negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
  - 2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
- 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - a. Pressure Class: Positive or negative 1-inch wg.



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- b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
  - 2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: A.
    - c. SMACNA Leakage Class for Rectangular: 4.
    - d. SMACNA Leakage Class for Round and Flat Oval: 2.
- F. Intermediate Reinforcement:
  - 1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
  - 2. Stainless-Steel Ducts:
    - a. Exposed to Airstream: Match duct material.
    - b. Not Exposed to Airstream: Match duct material.
  - 3. Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
- G. Elbow Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Velocity 1000 fpm or Lower:
      - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      - 2) Mitered Type RE 4 without vanes.
    - b. Velocity 1000 to 1500 fpm:
      - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
    - c. Velocity 1500 fpm or Higher:
      - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
  - 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

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- a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
  - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
  - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
    - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
    - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
    - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
    - 4) Radius-to Diameter Ratio: 1.5.
  - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
  - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- H. Branch Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry.
    - b. Rectangular Main to Round Branch: Conical spin in.
  - 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
    - a. Velocity 1000 fpm or Lower: 90-degree tap.
    - b. Velocity 1000 to 1500 fpm: Conical tap.
    - c. Velocity 1500 fpm or Higher: 45-degree lateral.

**END OF SECTION 23 3113**

**SECTION 233116**

**NONMETAL DUCTS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Extent of non-metal ductwork is indicated on drawings and by requirements of this section.
  - 2. Types of non-metal ductwork required for this project include the following:
    - a. Textile Air Dispersion Products.
- B. Related Requirements:
  - 1. Section 233113 "Metal Ducts" for single- and double-wall, rectangular and round ducts.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of the following products:
  - 1. Textile duct materials.
- B. Shop Drawings:
  - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - 2. Duct layout indicating sizes and pressure classes.
  - 3. Elevation of top of ducts.
  - 4. Dimensions of main duct runs from building grid lines.
  - 5. Fittings.
  - 6. Reinforcement and spacing.
  - 7. Seam and joint construction.
  - 8. Equipment installation based on equipment being used on Project.
  - 9. Hangers and supports, including methods for duct and building attachment and vibration isolation.

## **PART 2 - PRODUCTS**

### **2.1 TEXTILE DUCTS AND FITTINGS**

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Duct Sox Corporation.

### **2.2 TEXTILE AIR DISPERSION SYSTEM:**

- A. Hoops (IHS) System: Air diffusers shall be constructed with internal retention system.
1. System shall consist of an internal 360 degree hoop system, spaced 5' on center.
  2. System shall be installed with a one row suspension system located 1.5" above top-dead-center of the textile system.
  3. System attachment to cable or U-Track shall be made using Gliders spaced 12 inches.
  4. Available for diameters from 8" – 48".
  5. One row suspension options(must specify if multiple on same project)
    - a.
    - b. U-Track suspension hardware to include 8' sections of aluminum track, aluminum splice connectors, track endcaps and vertical cable support kits – consisting of a length of cable with cable connectors. Radius aluminum track must be included for all horizontal/flat radius sections.
      1. U-Track suspension
        - a. Impregnated steel cable(required for natatorium applications)
- B. TEXTILE
1. Verona
    - a. Textile Construction: Filament/filament twill polyester, fire retardant in accordance with UL 2518.
    - b. Air Permeability: 2 (+2/-1) CFM/ft<sup>2</sup> per ASTM D737, Frazier
    - c. Weight: 6.8 oz. /yd<sup>2</sup> per ASTM D3776
    - d. Warranty: 10 years
  2. Textile Color
    - a. Standard: blue, white, tan, red, green, silver, black
    - b. Custom
- C. TEXTILE SYSTEM FABRICATION REQUIREMENTS:
1. Textile system to be constructed in modular lengths (zippered) with proper radial securing clips along the length of the system.
  2. Integrated air dispersion shall be specified and approved by manufacturer. (select only those that apply)
    - a. Linear Vents
      1. Air dispersion accomplished by linear vent and permeable fabric. Linear vents must be sized in 1 CFM per linear foot increments (based on .5" SP), starting a 1 CFM through 90 CFM per linear foot. Linear vent is to consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents. Linear vents should also be designed to minimize dusting on fabric surface.

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2. Size of vent openings and location of linear vents to be specified and approved by manufacturer.
  3. Inlet connection to metal duct via fabric draw band with anchor patches as supplied by manufacturer. Anchor patches to be secured to metal duct via. zip screw fastener – supplied by contractor.
  4. Inlet connection includes zipper for easy removal / maintenance.
  5. Lengths to include required intermediate zippers as specified by manufacturer.
  6. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.
  7. End cap includes zipper for easy maintenance.
  8. Each section of the textile shall include identification labels documenting order number, section diameter, section length, piece number, code certifications and other pertinent information.
- D. DESIGN PARAMETERS:
1. Textile air diffusers shall be designed from 0.25" water gage minimum to 3.1" maximum, with 0.5" as the standard.
  2. Textile air diffusers shall be limited to design temperatures between 0 degrees F and 180 degrees F (-17.8 degrees C and 82 degrees C).
  3. System overall design; diameter, length, airflow, operating static pressure and dispersion shall be designed or approved by the manufacturer.
  4. Do not use textile diffusers in concealed locations.
  5. Use textile air dispersion systems only for positive pressure air distribution components of the mechanical ventilation system.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF TEXTILE AIR DISPERSION SYSTEM:**

- A. Install chosen suspension system in accordance with the requirements of the manufacturer. Instructions for installation shall be provided by the manufacturer with product.

#### **3.2 CLEANING AND PROTECTION:**

- A. Clean air handling unit and ductwork prior to the DuctSox system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.
- B. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.
- C. If DuctSox systems become soiled during installation, they should be removed and cleaned following the manufacturers standard terms of laundry.

**END OF SECTION 233116**



**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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Manual volume dampers.
  - 2. Control dampers.
  - 3. Flange connectors.
  - 4. Turning vanes.
  - 5. Remote damper operators.
  - 6. Duct-mounted access doors.
  - 7. Flexible connectors.
  - 8. Duct accessory hardware.
- B. Related Requirements:
  - 1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
  - 2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
  - 3. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
  - 4. Section 284621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
  - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
    - a. Special fittings.
    - b. Manual volume damper installations.
    - c. Control-damper installations.

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- d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
- e. Duct security bars.
- f. Wiring Diagrams: For power, signal, and control wiring.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 ASSEMBLY DESCRIPTION**

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

#### **2.2 MATERIALS**

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90.
  - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.



## **2.3 MANUAL VOLUME DAMPERS**

### **A. Low-Leakage, Steel, Manual Volume Dampers:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. American Warming and Ventilating; a Mestek Architectural Group company.
  - b. Flex-Tek Group.
  - c. McGill AirFlow LLC.
  - d. Nailor Industries Inc.
  - e. Pottorff.
  - f. Ruskin Company.
  - g. Trox USA Inc.
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:
  - a. Hat shaped.
  - b. 0.094-inch-thick, galvanized sheet steel.
  - c. Mitered and welded corners.
  - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
  - a. Multiple or single blade.
  - b. Parallel- or opposed-blade design.
  - c. Stiffen damper blades for stability.
  - d. Galvanized, roll-formed steel, 0.064 inch thick.
7. Blade Axles: Galvanized steel.
8. Bearings:
  - a. Oil-impregnated bronze or Molded synthetic.
  - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:
  - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

### **B. Low-Leakage, Aluminum, Manual Volume Dampers:**

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Air Balance; a division of MESTEK, Inc.
    - b. American Warming and Ventilating; a Mestek Architectural Group company.
    - c. McGill AirFlow LLC.
    - d. Nailor Industries Inc.
    - e. Pottorff.
    - f. Ruskin Company.
    - g. Trox USA Inc.
  2. Comply with AMCA 500-D testing for damper rating.
  3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
  4. Suitable for horizontal or vertical applications.
  5. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
  6. Blades:
    - a. Multiple or single blade.
    - b. Parallel- or opposed-blade design.
    - c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
    - d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
  7. Blade Axles: Galvanized steel.
  8. Bearings:
    - a. Oil-impregnated bronze or Molded synthetic.
    - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  9. Blade Seals: Neoprene.
  10. Jamb Seals: Cambered stainless steel.
  11. Tie Bars and Brackets: Galvanized steel.
  12. Accessories:
    - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- C. Jackshaft:
1. Size: 0.5-inch diameter.
  2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
  3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware:

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1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

## **2.4 CONTROL DAMPERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Tamco, Inc.
  2. Ruskin Company.
- B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
1. Hat shaped.
  2. 0.094-inch-thick, galvanized sheet steel.
  3. Mitered and welded corners.
- D. Blades:
1. Multiple blade with maximum blade width of 6 inches.
  2. Parallel- and opposed-blade design.
  3. Extruded Aluminum Airfoil.
  4. 0.064 inch thick single skin.
  5. Blade Edging: Closed-cell neoprene.
- E. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
1. Oil-impregnated bronze or Molded synthetic.
  2. Dampers in ducts with pressure classes of 6-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  3. Thrust bearings at each end of every blade.
  - 4.

## **2.5 FLANGE CONNECTORS**

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

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1. CL WARD & Family Inc.
  2. Ductmate Industries, Inc.
  3. Hardcast, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

## **2.6 TURNING VANES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aero-Dyne Sound Control Co.
  2. Ductmate Industries, Inc.
  3. Duro Dyne Inc.
  4. METALAIRE, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall.
- F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

## **2.7 REMOTE DAMPER OPERATORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Pottorff.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Copper.

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- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Stainless steel.

## **2.8 DUCT-MOUNTED ACCESS DOORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. American Warming and Ventilating; a Mestek Architectural Group company.
  - 2. Cesco Products; a division of MESTEK, Inc.
  - 3. Ductmate Industries, Inc.
  - 4. Flexmaster U.S.A., Inc.
  - 5. Greenheck Fan Corporation.
  - 6. McGill AirFlow LLC.
  - 7. Nailor Industries Inc.
  - 8. Pottorff.
  - 9. United Enertech.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
  - 1. Door:
    - a. Double wall, rectangular.
    - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    - c. Vision panel.
    - d. Hinges and Latches: 1-by-1-inchbutt 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.
- C. Pressure Relief Access Door:
  - 1. Door and Frame Material: Galvanized sheet steel.
  - 2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.

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3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch-thick, fibrous-glass or polystyrene-foam board.

## **2.9 DUCT ACCESS PANEL ASSEMBLIES**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. 3M.
  2. CL WARD & Family Inc.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- D. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

## **2.10 FLEXIBLE CONNECTORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. CL WARD & Family Inc.
  2. Ductmate Industries, Inc.
  3. Duro Dyne Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  1. Minimum Weight: 26 oz./sq. yd..
  2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

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3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
  1. Minimum Weight: 24 oz./sq. yd..
  2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
  3. Service Temperature: Minus 50 to plus 250 deg F.
- G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
  1. Minimum Weight: 14 oz./sq. yd..
  2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
  3. Service Temperature: Minus 67 to plus 500 deg F.
- H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
  1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
  2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

## **2.11 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.

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- 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. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
  - 1. Install steel volume dampers in steel ducts.
  - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers according to UL listing.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. On both sides of duct coils.
  - 2. Upstream and downstream from duct filters.
  - 3. At outdoor-air intakes and mixed-air plenums.
  - 4. At drain pans and seals.
  - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - 7. At each change in direction and at maximum 50-foot spacing.
  - 8. Upstream and downstream from turning vanes.
  - 9. Upstream or downstream from duct silencers.
  - 10. Control devices requiring inspection.
  - 11. Elsewhere as indicated.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
  - 1. One-Hand or Inspection Access: 8 by 5 inches.
  - 2. Two-Hand Access: 12 by 6 inches.
  - 3. Head and Hand Access: 18 by 10 inches.



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4. Head and Shoulders Access: 21 by 14 inches.
  5. Body Access: 25 by 14 inches.
  6. Body plus Ladder Access: 25 by 17 inches.
- K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
- M. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- N. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- O. Connect diffusers to ducts directly or with maximum 48-inch lengths of flexible duct clamped or strapped in place.
- P. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- Q. Install duct test holes where required for testing and balancing purposes.
- R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

### **3.2 FIELD QUALITY CONTROL**

- A. Tests and Inspections:
1. Operate dampers to verify full range of movement.
  2. Inspect locations of access doors and verify that purpose of access door can be performed.
  3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
  4. Inspect turning vanes for proper and secure installation.
  5. Operate remote damper operators to verify full range of movement of operator and damper.

**END OF SECTION 23 3300**



## **SECTION 23 3346**

### **FLEXIBLE DUCTS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Insulated flexible ducts.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: For flexible ducts.
  - 1. Include plans showing locations and mounting and attachment details.

#### **PART 2 - PRODUCTS**

##### **2.1 ASSEMBLY DESCRIPTION**

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
- D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

## 2.2 INSULATED 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.
- B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
  - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
  - 2. Maximum Air Velocity: 4000 fpm.
  - 3. Temperature Range: Minus 10 to plus 160 deg F.
  - 4. Insulation R-Value: R6.
- C. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
  - 1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
  - 2. Maximum Air Velocity: 4000 fpm.
  - 3. Temperature Range: Minus 20 to plus 175 deg F.
  - 4. Insulation R-Value: R6.
- D. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized 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 20 to plus 210 deg F.
  - 4. Insulation R-Value: R6.
- E. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized 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 20 to plus 210 deg F.
  - 4. Insulation R-Value: R6.
- F. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; aluminized vapor-barrier film.
  - 1. Pressure Rating: 8-inch wg positive or negative.
  - 2. Maximum Air Velocity: 5000 fpm.
  - 3. Temperature Range: Minus 20 to plus 250 deg F.
  - 4. Insulation R-Value: R6.

## **2.3 FLEXIBLE DUCT CONNECTORS**

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
- B. Non-Clamp Connectors: Adhesive plus sheet metal screws.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install flexible ducts 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 in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- C. Connect diffusers connect to ducts directly or with maximum 48-inch lengths of flexible duct clamped or strapped in place.
- D. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- E. Installation:
  - 1. Install ducts fully extended.
  - 2. Do not bend ducts across sharp corners.
  - 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
  - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
  - 5. Install flexible ducts in a direct line, without sags, twists, or turns.
- F. Supporting Flexible Ducts:
  - 1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
  - 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
  - 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
  - 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

**END OF SECTION 23 3346**



**SECTION 233350**

**LOUVERS AND VENTS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. Section Includes:
  - 1. Fixed, extruded-aluminum louvers.

**1.2 DEFINITIONS**

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.
- C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

**1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
  - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

**1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain louvers and vents from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.
- B. Welding: Qualify procedures and personnel according to the following:
  - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
  - 2. AWS D1.3, "Structural Welding Code - Sheet Steel."
  - 3. AWS D1.6, "Structural Welding Code - Stainless Steel."
- C. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

**1.5 PROJECT CONDITIONS**

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS**

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.
- C. Fasteners: Use types and sizes to suit unit installation conditions.
  - 1. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
  - 2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
  - 3. For color-finished louvers, use fasteners with heads that match color of louvers.
- D. Post installed Fasteners for Concrete and Masonry: Torque controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

### **2.2 FABRICATION, GENERAL**

- A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
  - 1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
  - 2. Horizontal Mullions: Provide horizontal mullions at joints unless continuous vertical assemblies are indicated.
- C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
- D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
  - 1. Frame Type: Channel unless otherwise indicated.
- E. Include supports, anchorages, and accessories required for complete assembly.
- F. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less.
  - 1. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.



- G. Provide sub-sills made of same material as louvers or extended sills for recessed louvers.
- H. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

## **2.3 FIXED, EXTRUDED-ALUMINUM LOUVERS**

- A. Horizontal, Drainable-Blade Louver:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Carnes Company, Inc.
    - b. Greenheck Fan Corporation.
    - c. Ruskin Company; Tomkins PLC.
    - d. United Enertech Corp.
    - e. Vent Products Company, Inc.
  - 2. Louver Depth: 4 inches.
  - 3. Frame and Blade Nominal Thickness: Not less than 0.060 inch for blades and 0.080 inch for frames.
  - 4. Mullion Type: Exposed.
  - 5. Louver Performance Ratings:
    - a. Free Area: Not less than 7.0 sq. ft. for 48-inch- wide by 48-inch- high louver.
    - b. Point of Beginning Water Penetration: Not less than 800 fpm.
    - c. Air Performance: Not more than 0.10-inch wg static pressure drop at 800-fpm free-area intake velocity.
    - d. Air Performance: Not more than 0.15-inch wg static pressure drop at 1000-fpm free-area exhaust velocity.
  - 6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

## **2.4 LOUVER SCREENS**

- A. General: Provide screen at each exterior louver.
  - 1. Screen Location for Fixed Louvers: Interior face.
  - 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
  - 1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
  - 2. Finish: Same finish as louver frames to which louver screens are attached.
  - 3. Type: Non-rewirable, U-shaped frames.
- D. Louver Screening for Aluminum Louvers:
  - 1. Bird Screening: Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

## **2.5 FINISHES, GENERAL**

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

## **2.6 ALUMINUM FINISHES**

- A. Finish louvers after assembly.
- B. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
  - 1. Color and Gloss: As selected by Architect from manufacturer's full range.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 PREPARATION**

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

### **3.3 INSTALLATION**

- A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- F. Protect unpainted galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- G. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 Section "Joint Sealants" for sealants applied during louver installation.

**3.4 ADJUSTING AND CLEANING**

- A. Test operation of adjustable louvers and adjust as needed to produce fully functioning units that comply with requirements.
- B. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- D. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
  - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of and is compatible with, factory-applied finish coating.

**END OF SECTION 23 3350**



**SECTION 23 3416**

**CENTRIFUGAL HVAC FANS**

**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: For each product.
  - 1. Airfoil centrifugal fans.
  - 2. Plenum fans.

**1.3 ACTION SUBMITTALS**

- A. Product Data:
  - 1. Include rated capacities, furnished specialties, and accessories for each fan.
  - 2. Certified fan performance curves with system operating conditions indicated.
  - 3. Certified fan sound-power ratings.
  - 4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - 5. Material thickness and finishes, including color charts.
  - 6. Dampers, including housings, linkages, and operators.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - 5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- B. Field quality-control reports.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 PERFORMANCE REQUIREMENTS**

- A. AMCA Compliance:
  - 1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
  - 2. Operating Limits: Classify according to AMCA 99.
- B. 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.

#### **2.2 AIRFOIL CENTRIFUGAL FANS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Acme Engineering & Manufacturing Corp.
  - 2. Chicago Blower Corporation.
  - 3. Cincinnati Fan.
  - 4. CML Northern Blower Inc.
  - 5. Howden Buffalo Inc.
  - 6. Twin City
  - 7. Cook
  - 8. Greenheck
- B. Description:
  - 1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

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2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Airfoil Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.

## 2.3 PLENUM FANS

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

1. Acme Engineering & Manufacturing Corp.
2. Chicago Blower Corporation.
3. Cincinnati Fan.

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4. CML Northern Blower Inc.
5. Howden Buffalo Inc.
6. Twin City
7. Cook
8. Greenheck

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Airfoil Wheels:

1. Single-width-single-inlet construction with smooth-curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
2. Ball-Bearing Rating Life: ABMA 9, L10 at 120,000 hours.
3. Roller-Bearing Rating Life: ABMA 11, L10 at 120,000 hours.

## **2.4 MOTORS**

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

## **2.5 SOURCE QUALITY CONTROL**

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.



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- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install centrifugal fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
  - 1. Install centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
- F. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.
- G. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices.
  - 1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
- H. Install units with clearances for service and maintenance.
- I. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

### **3.2 CONNECTIONS**

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

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- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

### **3.3 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Verify that cleaning and adjusting are complete.
  - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - 5. Adjust belt tension.
  - 6. Adjust damper linkages for proper damper operation.
  - 7. Verify lubrication for bearings and other moving parts.
  - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - 9. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
  - 10. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### **3.4 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

**END OF SECTION 23 3416**

**SECTION 23 3423**

**HVAC POWER VENTILATORS**

**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. Centrifugal roof ventilators.
  - 2. In-line centrifugal fans.

**1.3 PERFORMANCE REQUIREMENTS**

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
- B. Operating Limits: Classify according to AMCA 99.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
  - 1. Certified fan performance curves with system operating conditions indicated.
  - 2. Certified fan sound-power ratings.
  - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - 4. Material thickness and finishes, including color charts.
  - 5. Dampers, including housings, linkages, and operators.
  - 6. Roof curbs.
  - 7. Fan speed controllers.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Wiring Diagrams: For power, signal, and control wiring.

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**1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Reflected ceiling 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. Roof framing and support members relative to duct penetrations.
  - 2. Ceiling suspension assembly members.
  - 3. Size and location of initial access modules for acoustical tile.

**1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

**1.7 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

**1.8 COORDINATION**

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

**PART 2 - PRODUCTS**

**2.1 CENTRIFUGAL ROOF VENTILATORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Aerovent; a division of Twin City Fan Companies, Ltd.
  - 2. American Coolair Corporation.
  - 3. Carnes Company.
  - 4. Greenheck Fan Corporation.

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5. JencoFan.
  6. Loren Cook Company.
  7. PennBarry.
  8. Twin City
- B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
  2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  2. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
  3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
  4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
- E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Built-in raised cant and mounting flange.
  2. Overall Height: 16 inches.
  3. Sound Curb: Curb with sound-absorbing insulation.
  4. Pitch Mounting: Manufacture curb for roof slope.
  5. Metal Liner: Galvanized steel.

## 2.2 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Manufacturing Corp.
  2. American Coolair Corporation.
  3. Carnes Company.
  4. Greenheck Fan Corporation.
  5. JencoFan.
  6. Loren Cook Company.
  7. Peerless Blowers.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

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- C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.
- D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- E. Accessories:
  - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 2. Companion Flanges: For inlet and outlet duct connections.
  - 3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
  - 4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

## **2.3 MOTORS**

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
  - 1. Install power ventilators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch.
- F. Install units with clearances for service and maintenance.

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- G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

### **3.2 CONNECTIONS**

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.3 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Verify that shipping, blocking, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - 3. Verify that cleaning and adjusting are complete.
  - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - 5. Adjust belt tension.
  - 6. Adjust damper linkages for proper damper operation.
  - 7. Verify lubrication for bearings and other moving parts.
  - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  - 10. Shut unit down and reconnect automatic temperature-control operators.
  - 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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- D. Prepare test and inspection reports.

**3.4 ADJUSTING**

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

**END OF SECTION 23 3423**



## **SECTION 23 3600**

### **AIR TERMINAL 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.

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Shutoff, single-duct air terminal units.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of air terminal unit.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air terminal units.
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Instructions for resetting minimum and maximum air volumes.
    - b. Instructions for adjusting software set points.

## **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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

### **2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Anemostat Products; a Mestek company.
  - 2. Carnes Company.
  - 3. ENVIRO-TEC; by Johnson Controls, Inc.
  - 4. JCI / York
  - 5. Krueger.
  - 6. METALAIRE, Inc.
  - 7. Nailor Industries Inc.
  - 8. Price Industries.
  - 9. Titus.
  - 10. Trane.
  - 11. Carrier.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.040-inch- thick galvanized steel, single wall.
  - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass duct liner.
  - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
  - 3. Air Outlet: S-slip and drive connections, size matching inlet size.
  - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
  - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero

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to 140 deg F, shall be impervious to moisture and fungus, shall be suitable for 10-inch wg static pressure, and shall be factory tested for leaks.

- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
  - 1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 6-inch wg inlet static pressure.
  - 2. Damper Position: Normally open.
- F. Hydronic Heating Coils: 2-row coil with copper tubes and mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- G. Controls:
  - 1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
  - 2. System-powered, wall-mounted thermostat.

### **PART 3 - EXECUTION**

#### **3.1 HANGER AND SUPPORT INSTALLATION**

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
  - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
  - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

#### **3.2 TERMINAL UNIT INSTALLATION**

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

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- B. Install wall-mounted thermostats.

### **3.3 CONNECTIONS**

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

### **3.4 IDENTIFICATION**

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

### **3.5 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
  - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Air terminal unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### **3.6 STARTUP SERVICE**

- A. Perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.

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2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

**3.7 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

**END OF SECTION 23 3600**



**SECTION 23 3713.13**

**AIR DIFFUSERS**

**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. Round ceiling diffusers.
  - 2. Rectangular and square ceiling diffusers.
  - 3. Perforated diffusers.
  - 4. Louver face diffusers.
  - 5. Linear bar diffusers.
  - 6. Linear slot diffusers.
  - 7. High-capacity drum louver diffusers.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
  - 2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

## **PART 2 - PRODUCTS**

### **2.1 ROUND CEILING DIFFUSERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Anemostat Products; a Mestek company.
  - 2. Carnes Company.
  - 3. Hart & Cooley Inc.
  - 4. METALAIRE, Inc.
  - 5. Nailor Industries Inc.
  - 6. Price Industries.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Aluminum.
- D. Finish: Baked enamel, white.
- E. Dampers: Radial opposed blade.
- F. Accessories:
  - 1. Equalizing grid.
  - 2. Plaster ring.

### **2.2 RECTANGULAR AND SQUARE CEILING DIFFUSERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Anemostat Products; a Mestek company.
  - 2. Carnes Company.
  - 3. Hart & Cooley Inc.
  - 4. Krueger.
  - 5. METALAIRE, Inc.
  - 6. Nailor Industries Inc.
  - 7. Price Industries.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Aluminum.
- D. Finish: Baked enamel, white.
- E. Dampers: Combination damper and grid.



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F. Accessories:

1. Equalizing grid.
2. Plaster ring.

**2.3 PERFORATED DIFFUSERS**

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

1. A-J Manufacturing Co., Inc.
2. Carnes Company.
3. Hart & Cooley Inc.
4. Krueger.
5. METALAIRE, Inc.
6. Nailor Industries Inc.
7. Price Industries.
8. Titus.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Steel backpan and pattern controllers, with aluminum face.

D. Finish: Baked enamel, white.

E. Duct Inlet: Round.

F. Dampers: Opposed blade.

G. Accessories:

1. Equalizing grid.
2. Plaster ring.

**2.4 LOUVER FACE DIFFUSERS**

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

1. A-J Manufacturing Co., Inc.
2. Anemostat Products; a Mestek company.
3. Carnes Company.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. Price Industries.

B. Devices shall be specifically designed for variable-air-volume flows.

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- C. Material: Aluminum.
- D. Finish: Baked enamel, white.
- E. Pattern: Two-way core style.
- F. Dampers: Combination damper and grid.
- G. Accessories:
  - 1. Square to round neck adaptor.
  - 2. Adjustable pattern vanes.
  - 3. Throw reducing vanes.
  - 4. Equalizing grid.

## **2.5 LINEAR BAR DIFFUSERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Anemostat Products; a Mestek company.
  - 2. Carnes Company.
  - 3. Hart & Cooley Inc.
  - 4. Krueger.
  - 5. METALAIRE, Inc.
  - 6. Nailor Industries Inc.
  - 7. Price Industries.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Aluminum.
- D. Finish: Baked enamel, white.
- E. Two-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
- F. Frame: 1 inch wide.
- G. Mounting: Countersunk screw.
- H. Damper Type: Adjustable opposed-blade assembly.

## **2.6 LINEAR SLOT DIFFUSERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Anemostat Products; a Mestek company.

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2. Carnes Company.
  3. Hart & Cooley Inc.
  4. Krueger.
  5. METALAIRE, Inc.
  6. Nailor Industries Inc.
  7. Price Industries.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material - Shell: Aluminum, insulated.
- D. Material - Pattern Controller and Tees: Aluminum.
- E. Finish - Face and Shell: Baked enamel, black.
- F. Finish - Pattern Controller: Baked enamel, black.
- G. Finish - Tees: Baked enamel, white.

**2.7 HIGH-CAPACITY DRUM LOUVER DIFFUSERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Anemostat Products; a Mestek company.
  2. Carnes Company.
  3. Hart & Cooley Inc.
  4. Krueger.
  5. METALAIRE, Inc.
  6. Nailor Industries Inc.
  7. Price Industries.
- B. Airflow Principle: Extended distance for high airflow rates.
- C. Material: Aluminum, heavy gage extruded.
- D. Finish: White baked acrylic.
- E. Border: 1-1/4-inch width with countersunk screw holes.
- F. Gasket between drum and border.
- G. Body: Drum shaped; adjustable vertically.
- H. Blades: Individually adjustable horizontally.
- I. Mounting: Surface to duct or wall.
- J. Accessories:

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1. Opposed-blade steel damper.
2. Duct-mounting collars with countersunk screw holes.

**2.8 SOURCE QUALITY CONTROL**

- A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.2 INSTALLATION**

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

**3.3 ADJUSTING**

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

**END OF SECTION 23 3713.13**

**SECTION 23 3713.23**

**REGISTERS AND GRILLES**

**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. Adjustable blade face registers and grilles.
  - 2. Fixed face registers and grilles.
  - 3. Linear bar grilles.
- B. Related Requirements:
  - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
  - 2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - 2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

**PART 2 - PRODUCTS**

**2.1 REGISTERS**

- A. Adjustable Blade Face Register:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Anemostat Products; a Mestek company.

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- b. Carnes Company.
  - c. Hart & Cooley Inc.
  - d. Krueger.
  - e. METALAIRE, Inc.
  - f. Nailor Industries Inc.
  - g. Price Industries.
- 2. Material: Steel.
- 3. Finish: Baked enamel, white.
- 4. Face Blade Arrangement: Horizontal spaced 1/2 inch apart.
- 5. Core Construction: Integral.
- 6. Damper Type: Adjustable opposed blade.
- 7. Accessories:
  - a. Rear-blade gang operator.

B. Fixed Face Register:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. A-J Manufacturing Co., Inc.
  - b. Anemostat Products; a Mestek company.
  - c. Carnes Company.
  - d. Hart & Cooley Inc.
  - e. Krueger.
  - f. Nailor Industries Inc.
  - g. Price Industries.
- 2. Material: Steel.
- 3. Finish: Baked enamel, white.
- 4. Face Blade Arrangement: Horizontal spaced 1/2 inch apart.
- 5. Face Arrangement: Perforated core.
- 6. Core Construction: Integral.
- 7. Damper Type: Adjustable opposed blade.
- 8.

## 2.2 GRILLES

A. Adjustable Blade Face Grille:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. A-J Manufacturing Co., Inc.
  - b. Anemostat Products; a Mestek company.
  - c. Carnes Company.
  - d. Hart & Cooley Inc.
  - e. Krueger.
  - f. METALAIRE, Inc.

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- g. Nailor Industries Inc.
    - h. Price Industries.
  - 2. Material: Steel.
  - 3. Finish: Baked enamel, white.
  - 4. Core Construction: Integral.
  - 5. Accessories:
    - a. Rear-blade gang operator.
- B. Fixed Face Grille:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Anemostat Products; a Mestek company.
    - b. Carnes Company.
    - c. Hart & Cooley Inc.
    - d. Krueger.
    - e. Nailor Industries Inc.
    - f. Price Industries.
  - 2. Material: Steel.
  - 3. Finish: Baked enamel, white.
  - 4. Face Blade Arrangement: Horizontal; spaced 1/2 inch apart.
  - 5. Face Arrangement: Perforated core.
  - 6. Core Construction: Integral.
- C. Linear Bar Grilles
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. A-J Manufacturing Co., Inc.
    - b. Anemostat Products; a Mestek company.
    - c. Carnes Company.
    - d. Hart & Cooley Inc.
    - e. Krueger.
    - f. Nailor Industries Inc.
    - g. Price Industries.
  - 2. Material: Steel.
  - 3. Finish: Baked enamel, white.
  - 4. Face Blade Arrangement: Horizontal; spaced 1/2 inch apart.
  - 5. Face Arrangement: Perforated core.
  - 6. Core Construction: Integral.
  - 7. Distribution plenum.
    - a. Internal insulation.
    - b. Inlet damper.
  - 8. Damper Type: Adjustable opposed blade.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install registers and grilles level and plumb.
- B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

#### **3.3 ADJUSTING**

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

**END OF SECTION 23 3713.23**



**SECTION 23 3723**

**HVAC GRAVITY VENTILATORS**

**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. Hooded ventilators.
  - 2. Goosenecks.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings: For gravity ventilators.
  - 1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
  - 2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:
- B. Welding certificates.

**1.5 COORDINATION**

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

## **PART 2 - PRODUCTS**

### **2.1 FABRICATION**

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

### **2.2 HOODED VENTILATORS**

- A. Description: Hooded rectangular penthouse for intake or relief air.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Carnes Company.
  - 2. Greenheck Fan Corporation.
  - 3. JencoFan.
  - 4. Loren Cook Company.
  - 5. PennBarry.
- C. Source Limitations: Obtain hooded ventilators from single manufacturer.
- D. Construction:
  - 1. Material: Galvanized steel, of thickness required to comply with structural performance requirements, but not less than 0.064-inch-thick base and 0.040-inch-thick hood; suitably reinforced.
  - 2. Material: Aluminum, of thickness required to comply with structural performance requirements, but not less than 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.
  - 3. Insulation: Mineral-fiber insulation and vapor barrier.
  - 4. Bird Screening: Aluminum, 1/2-inch-square mesh or flattened, expanded aluminum, 3/4-inch diamond mesh wire.
- E. Galvanized-Steel Finish:

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1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A 780/A 780M. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

F. Dampers:

1. Location: Hood neck.
2. Control: Gravity backdraft.

G. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 16 inches.

## 2.3 GOOSENECKS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of 0.052-inch-thick, galvanized-steel sheet.

B. Bird Screening: Aluminum, 1/2-inch-square mesh, 0.063-inch wire.

C. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A 780/A 780M. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches.

## **2.4 MATERIALS**

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.
- D. Stainless Steel Sheet: ASTM A 666, Type 304, with No. 4 finish.
- E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
  - 1. Use types and sizes to suit unit installation conditions.
  - 2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.
- F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.
- G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187/D 1187M.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with zinc-plated hardware. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."
- C. Install goosenecks on curb base where throat size exceeds 9 by 9 inches.
- D. Install gravity ventilators with clearances for service and maintenance.
- E. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."
- G. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

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### **3.2 CONNECTIONS**

- A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

### **3.3 ADJUSTING**

- A. Adjust damper linkages for proper damper operation.

**END OF SECTION 23 3723**



**SECTION 23 5700**

**HEAT EXCHANGERS FOR HVAC**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section includes shell-and-tube and plate heat exchangers.

**1.3 DEFINITIONS**

- A. TEMA: Tubular Exchanger Manufacturers Association.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
  - 2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Tube-removal space.
  - 2. Structural members to which heat exchangers will be attached.

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**1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

**1.7 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Structural failures including heat exchanger, storage tank, and supports.
    - b. Faulty operation of controls.
    - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
  - 2. Warranty Periods: From date of Substantial Completion.
    - a. Shell-and-Tube, Heat Exchangers:
      - 1) Tube Coil: One year(s).
    - b. Plate, Heat Exchangers:
      - 1) Plate-and-Frame Type: One year(s).

**PART 2 - PRODUCTS**

**2.1 SHELL-AND-TUBE HEAT EXCHANGERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. API Heat Transfer Inc.
  - 2. Armstrong Pumps, Inc.
  - 3. Flo Fab Inc.
  - 4. ITT Corporation.
  - 5. Alfa Laval Inc.
  - 6. Sondex
- B. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.
- C. Construction:
  - 1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.



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- 2. Fabricate and label shell-and-tube heat exchangers to comply with "TEMA Standards."
- D. Configuration: U-tube with removable bundle.
- E. Shell Materials: Steel.
- F. Head:
  - 1. Materials: Cast iron.
  - 2. Flanged and bolted to shell.
- G. Tube:
  - 1. Seamless copper tubes.
  - 2. Tube diameter is determined by manufacturer based on service.
- H. Tubesheet Materials: Steel.
- I. Baffles: Steel.
- J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attachappings to shell before testing and labeling.
  - 1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
  - 2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
- K. Support Saddles:
  - 1. Fabricated of material similar to shell.
  - 2. Fabricate foot mount with provision for anchoring to support.
  - 3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

## **2.2 GASKETED-PLATE HEAT EXCHANGERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Alfa Laval Inc.
  - 2. API Heat Transfer Inc.
  - 3. APV; SPX Corporation.
  - 4. Armstrong Pumps, Inc.
  - 5. Flo Fab Inc.
  - 6. ITT Corporation.
  - 7. TACO Comfort Solutions, Inc.

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- B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.
- C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
- D. Frame:
  - 1. Capacity to accommodate 20 percent additional plates.
  - 2. Painted carbon steel with provisions for anchoring to support.
- E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
  - 1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.
- F. End-Plate Material: Painted carbon steel.
- G. Tie Rods and Nuts: Steel or stainless steel.
- H. Plate Material: 0.039 inch thick before stamping; Type 304 stainless steel.
- I. Gasket Materials: EPDM rubber.
  - 1. Glue: Chlorine free.
- J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tapings to shell before testing and labeling.
  - 1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
  - 2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
- K. Enclose plates in solid stainless-steel removable shroud.

## **2.3 ACCESSORIES**

- A. Hangers and Supports:
  - 1. Custom, steel supports cradles for mounting on structural steel.
    - a. Minimum Number of Cradles: Three (3).
  - 2. Field-fabricated steel supports or cradles to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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- B. Shroud: Steel sheet.
- C. Miscellaneous Components for High-Temperature Hot-Water Unit: Control valve, valves, and piping.
- D. Pressure Relief Valves: Bronze, ASME rated and stamped.
  - 1. Pressure relief valve setting: 50 psig.

## **2.4 SOURCE QUALITY CONTROL**

- A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.
- B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.
- C. Heat exchangers will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
- B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 SHELL-AND-TUBE HEAT-EXCHANGER INSTALLATION**

- A. Equipment Mounting:
  - 1. Install heat exchangers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- B. Install heat exchangers on saddle supports.
- C. Heat-Exchanger Supports: Use factory-fabricated steel cradles and supports specifically designed for each heat exchanger.

### **3.3 GASKETED-PLATE HEAT-EXCHANGER INSTALLATION**

- A. Install gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.
- B. Install metal shroud over installed gasketed-plate heat exchanger according to manufacturer's written instructions.

### **3.4 CONNECTIONS**

- A. Comply with requirements for piping specified in other Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.
- C. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.
- D. Install shutoff valves at heat-exchanger inlet and outlet connections.
- E. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
- F. Install hose end valve to drain shell.
- G. Install thermometer on heat-exchanger and inlet and outlet piping, and install thermometer on heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."
- H. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

### **3.5 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Heat exchanger will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

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**3.6 CLEANING**

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

**3.7 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

**END OF SECTION 23 5700**



**SECTION 23 6200**

**PACKAGED COMPRESSOR AND CONDENSER 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.

**1.2 SUMMARY**

- A. Section includes packaged, refrigerant compressor and condenser units.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each compressor and condenser unit. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Shop Drawings: For compressor and condenser units. Include plans, elevations, sections, details, and attachments to other work.
  - 1. Wiring Diagrams: For power, signal, and control wiring.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - 1. Structural members to which compressor and condenser units will be attached.
  - 2. Liquid and vapor pipe sizes.
  - 3. Refrigerant specialties.
  - 4. Piping including connections, oil traps, and double risers.
  - 5. Compressors.
  - 6. Evaporators.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

## **1.6 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. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."
- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."
- D. ASME Compliance: Fabricate and label water-cooled compressor and condenser units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

## **1.7 COORDINATION**

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-In-Place Concrete" and Section 033053 "Miscellaneous Cast-In-Place Concrete."
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- C. Coordinate location of piping and electrical rough-ins.

## **1.8 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Compressor failure.
    - b. Condenser coil leak.
  - 2. Warranty Period: Five years from date of Substantial Completion.
  - 3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.
  - 4. Warranty Period (Components Other Than Compressor): Five years from date of Substantial Completion.
  - 5. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.



## **PART 2 - PRODUCTS**

### **2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Aeon
  - 2. JCI/York
  - 3. Daikin-McQuay
  - 4. Carrier
  - 5. Trane
- B. Description: Factory assembled and tested; consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
- C. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
  - 1. Motor: Single speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
  - 2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
  - 3. Accumulator: Suction tube.
- D. Refrigerant: R-410A.
- E. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
- F. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.
- G. Accessories:
  - 1. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
  - 2. Electronic programmable thermostat to control compressor and condenser unit and evaporator fan.
  - 3. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
  - 4. Filter-dryer.
  - 5. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
  - 6. Liquid-line solenoid.
  - 7. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
  - 8. Thermostatic expansion valve.

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- 9. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
- H. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

**2.2 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Aeon
  - 2. JCI/York
  - 3. Daikin-McQuay
  - 4. Carrier
  - 5. Trane
- B. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.
- C. Compressor: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and back-seating service access valves on suction and discharge ports.
  - 1. Capacity Control: On-off compressor cycling.
- D. Refrigerant: R-410A.
- E. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including sub-cooling circuit and back-seating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
- F. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
  - 1. Permanently lubricated, ball-bearing totally enclosed motors.
  - 2. Separate motor for each fan.
  - 3. Dynamically and statically balanced fan assemblies.
- G. Operating and safety controls include the following:
  - 1. Manual-reset, high-pressure cutout switches.
  - 2. Automatic-reset, low-pressure cutout switches.
  - 3. Low-oil-pressure cutout switch.
  - 4. Compressor-winding thermostat cutout switch.
  - 5. Three-leg, compressor-overload protection.
  - 6. Control transformer.
  - 7. Magnetic contactors for compressor and condenser fan motors.

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8. Timer to prevent excessive compressor cycling.

H. Accessories:

1. Electronic programmable thermostat to control compressor and condenser unit and evaporator fan.
2. Gage Panel: Package with refrigerant circuit suction and discharge gages.
3. Part-winding-start timing relay, circuit breakers, and contactors.

I. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:

1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
5. Condenser coil hail guard.

## 2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

## 2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate compressor and condenser units according to ARI 206/110.
- B. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."
- C. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install units level and plumb, firmly anchored in locations indicated.
- B. Install roof-mounting units on equipment supports specified in Section 077200 "Roof Accessories."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

### **3.3 CONNECTIONS**

- A. Comply with requirements for piping in other Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- C. Connect pre-charged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
- D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
  - 2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 5. Verify proper airflow over coils.
- C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

### **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 and perform the following:
    - a. Inspect for physical damage to unit casing.
    - b. Verify that access doors move freely and are weathertight.
    - c. Clean units and inspect for construction debris.
    - d. Verify that all bolts and screws are tight.
    - e. Adjust vibration isolation and flexible connections.
    - f. Verify that controls are connected and operational.
- B. Lubricate bearings on fan motors.
- C. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
- D. Adjust fan belts to proper alignment and tension.

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- E. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
- F. Measure and record airflow and air temperature rise over coils.
- G. Verify proper operation of condenser capacity control device.
- H. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- I. After startup and performance test, lubricate bearings.

**3.6 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain compressor and condenser units.

**END OF SECTION 23 6200**

**SECTION 23 6423.13**

**AIR-COOLED, SCROLL WATER CHILLERS**

**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 packaged, air-cooled, electric-motor-driven, scroll water chillers.

**1.3 DEFINITIONS**

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. DDC: Direct digital control.
- D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.
- E. GFI: Ground fault interrupt.
- F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- G. I/O: Input/output.
- H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.
- J. SCCR: Short-circuit current rating.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Performance at AHRI standard conditions and at conditions indicated.
  - 3. Performance at AHRI standard unloading conditions.
  - 4. Minimum evaporator flow rate.
  - 5. Refrigerant capacity of water chiller.
  - 6. Oil capacity of water chiller.
  - 7. Fluid capacity of evaporator.
  - 8. Characteristics of safety relief valves.
  - 9. Force and moment capacity of each piping connection.
- B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
  - 1. Assembled unit dimensions.
  - 2. Weight and load distribution.
  - 3. Required clearances for maintenance and operation.
  - 4. Size and location of piping and wiring connections.
  - 5. Diagrams for power, signal, and control wiring.

#### **1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings:
  - 1. Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
    - a. Structural supports.
    - b. Piping roughing-in requirements.
    - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
    - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
  - 2. Coordination drawings showing plan, section and elevation views, drawn to.
  - 3. Each view to show screened background with the following:
    - a. Column grids, beams, columns, and concrete housekeeping pads.
    - b. Layout with walls, floors, and roofs, including each room name and number.
    - c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as plumbing systems.



#### **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

#### **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Tool kit to include the following:
  - 1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
  - 2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
  - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch high.
  - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch high.
- B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

#### **1.8 QUALITY ASSURANCE**

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

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

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
- B. Package water chiller for export shipping.

#### **1.10 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

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1. Extended warranties include, but are not limited to, the following:
  - a. Complete chiller including refrigerant and oil charge.
  - b. Complete compressor and drive assembly including refrigerant and oil charge.
  - c. Refrigerant and oil charge.
    - 1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.
  - d. Parts only and labor.
2. Warranty Period: Five years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- B. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
  1. Allowable Capacity Tolerance: Zero percent.
  2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
  3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.
- C. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.
- D. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- G. Comply with NFPA 70.
- H. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- I. Operation Following Loss of Normal Power:
  1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when

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- power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
- 2. See drawings for equipment served by backup power systems.
- 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

J. Outdoor Installations:

- 1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.

## 2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. JCI/York.
  - 2. Daikin Applied
  - 3. Trane
  - 4. Carrier

## 2.3 MANUFACTURED UNITS

- A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.
- B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
- C. Security Package: Security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

## 2.4 CABINET

- A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
- B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
- C. Casing: Galvanized steel, all exterior piping shall be concealed within unit casing.
- D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.

## **2.5 COMPRESSOR-DRIVE ASSEMBLIES**

### **A. Compressors:**

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
  - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling.
  - a. Digital compressor unloading is an acceptable alternative to achieve capacity control.
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.
  - a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
6. Vibration Isolation: Mount individual compressors on vibration isolators.
  - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

### **B. Compressor Motors:**

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

### **C. Compressor Motor Controllers:**

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

## **2.6 REFRIGERATION**

- A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.
- B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff

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valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

- D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
  - 1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.
- E. Pressure Relief Device:
  - 1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - 2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
  - 3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

## **2.7 EVAPORATOR**

- A. Brazed Plate:
  - 1. Direct-expansion, single-pass, brazed-plate design.
  - 2. Type 304 or 316 stainless-steel construction.
  - 3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
  - 4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
  - 5. Inlet Strainer: Factory-furnished, 40-mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.
- B. Flow Switch: Factory-furnished and -installed, thermal-type flow switch wired to chiller operating controls.
- C. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

## **2.8 AIR-COOLED CONDENSER**

- A. Coil(s) with integral subcooling on each circuit.
- B. Copper Tube with Plate Fin Coils:
  - 1. Construct coils of copper tubes mechanically bonded to aluminum with precoated epoxy-phenolic fins.
- C. Aluminum Microchannel Coils:

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1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
  2. Single- or multiple-pass arrangement.
  3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.
- D. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- E. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
- F. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.
- G. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

## 2.9 INSULATION

- A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C 534/C 534M, Type I for tubular materials and Type II for sheet materials.
1. Thickness: 1-1/2 inches.
- B. Adhesive: As recommended by insulation manufacturer.
- C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
1. Apply adhesive to 100 percent of insulation contact surface.
  2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
  3. Seal seams and joints to provide a vapor barrier.
  4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
  5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
  6. Field-Applied Insulation:
    - a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
    - b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.

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- c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
- d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

**2.10 ELECTRICAL**

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
- C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
- D. Wiring shall be numbered and color-coded to match wiring diagram.
- E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch length of liquidtight or flexible metallic conduit.
- F. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.
- G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
  - 1. 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 60947-4-1.
  - 2. NEMA KS 1, heavy-duty, non-fusible switch.
  - 3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- H. Each motor shall have overcurrent protection.
- I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
- J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
- K. Power Factor Correction: Capacitors to correct power factor to 0.90 at full load.
- L. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- M. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.
- N. Service Receptacle:

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1. Unit-mounted, 120-V GFI duplex receptacle.
2. Power receptacle from chiller internal electrical power wiring.

O. Indicate the following for water chiller electrical power supply:

1. Current, phase to phase, for all three phases.
2. Voltage, phase to phase and phase to neutral for all three phases.
3. Three-phase real power (kilowatts).
4. Three-phase reactive power (kilovolt amperes reactive).
5. Power factor.
6. Running log of total power versus time (kilowatt hours).
7. Fault log, with time and date of each.

## 2.11 CONTROLS

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
- D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:
1. Date and time.
  2. Operating or alarm status.
  3. Operating hours.
  4. Outside-air temperature if required for chilled-water reset.
  5. Temperature and pressure of operating set points.
  6. Chilled-water entering and leaving temperatures.
  7. Refrigerant pressures in evaporator and condenser.
  8. Saturation temperature in evaporator and condenser.
  9. No cooling load condition.
  10. Elapsed time meter (compressor run status).
  11. Pump status.
  12. Antirecycling timer status.
  13. Percent of maximum motor amperage.
  14. Current-limit set point.
  15. Number of compressor starts.
  16. Alarm history with retention of operational data before unit shutdown.
  17. Superheat.
- E. Control Functions:
1. Manual or automatic startup and shutdown time schedule.
  2. Capacity control based on evaporator leaving-fluid temperature.



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3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
  4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water temperature.
  5. Current limit and demand limit.
  6. Condenser-water temperature.
  7. External water chiller emergency stop.
  8. Antirecycling timer.
  9. Automatic lead-lag switching.
- F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1. Low evaporator pressure or high condenser pressure.
  2. Low chilled-water temperature.
  3. Refrigerant high pressure.
  4. High or low oil pressure.
  5. High oil temperature.
  6. Loss of chilled-water flow.
  7. Loss of condenser-water flow.
  8. Control device failure.
- G. BAS System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.
1. Hardwired I/O Points:
    - a. Monitoring: On/off status, common trouble alarm.
    - b. Control: On/off operation, chilled-water discharge temperature set-point adjustment.
  2. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.
- H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquidtight or flexible metallic conduit.

## **2.12 ACCESSORIES**

- A. Factory-furnished spring isolators for field installation.
1. Spring Deflection: 2 inches.

## **2.13 SOURCE QUALITY CONTROL**

- A. Perform functional test of water chillers before shipping.

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- B. Factory performance test water chillers, before shipping, according to AHRI 550/590.
  - 1. Test the following conditions:
    - a. Design conditions indicated.
    - b. AHRI 550/590 part-load points.
  - 2. Allow Owner access to place where water chillers are being tested. Notify Owner 14 days in advance of testing.
- C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
  - 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 WATER CHILLER INSTALLATION**

- A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.
- C. Install water chillers on support structure indicated.
- D. Equipment Mounting:
  - 1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- E. Maintain manufacturer's recommended clearances for service and maintenance.
- F. Maintain clearances required by governing code.

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- G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- H. Install separate devices furnished by manufacturer and not factory installed.
  - 1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

### **3.3 PIPING CONNECTIONS**

- A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to chillers, allow space for service and maintenance.
- D. Evaporator Fluid Connections:
  - 1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
  - 2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
  - 3. Make connections to water chiller with a union flange or mechanical coupling.
- E. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.
- F. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

### **3.4 ELECTRICAL POWER CONNECTIONS**

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

### **3.5 CONTROLS CONNECTIONS**

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

### **3.6 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
  - 2. Verify that pumps are installed and functional.
  - 3. Verify that thermometers and gages are installed.
  - 4. Operate water chiller for run-in period.
  - 5. Check bearing lubrication and oil levels.
  - 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
  - 7. Verify proper motor rotation.
  - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  - 9. Verify and record performance of chilled-water flow and low-temperature interlocks.
  - 10. Verify and record performance of water chiller protection devices.
  - 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- E. Prepare a written startup report that records results of tests and inspections.

### **3.7 DEMONSTRATION**

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

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1. Instructor shall be factory trained and certified.
2. Provide not less than eight hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

**END OF SECTION 23 6423.13**



**SECTION 23 7313.16**

**INDOOR, SEMI-CUSTOM AIR-HANDLING 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.

**1.2 SUMMARY**

- A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each air-handling unit.
  - 1. Unit dimensions and weight.
  - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
  - 3. Fans:
    - a. Certified fan-performance curves with system operating conditions indicated.
    - b. Certified fan-sound power ratings.
    - c. Fan construction and accessories.
    - d. Motor ratings, electrical characteristics, and motor accessories.
  - 4. Certified coil-performance ratings with system operating conditions indicated.
  - 5. Dampers, including housings, linkages, and operators.
  - 6. Filters with performance characteristics.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor 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. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
  - 2. Support location, type, and weight.
  - 3. Field measurements.

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**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

**1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set(s) for each air-handling unit.

**1.7 COORDINATION**

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

**PART 2 - PRODUCTS**

**2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

**2.2 INDOOR, SEMI-CUSTOM AIR-HANDLING UNIT MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Daikin Applied.
  - 2. York/JCI.
  - 3. Trane
  - 4. Carrier



## 2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
- B. High Pressure Low Leakage Construction - The casing leakage rate shall not exceed 1% of supply air volume at design static pressure up to positive or negative 8 inches water column. Cabinet leakage shall not exceed Class 6 leakage per ASHRAE Standard 111.
  - 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
  - 2. Flooring: Tread plate flooring - The floor plate shall be furnished with minimum 0.125 inch thick aluminum tread plate.
  - 3. Casing Joints: Sheet metal screws or pop rivets.
  - 4. Sealing: Seal all joints with water-resistant sealant
  - 5. Factory Finish – Standard Galvanized-Steel Casing.
  - 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Casing Insulation and Adhesive:
  - 1. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
  - 2. The inner liner shall be constructed of G90 galvanized steel.
  - 3. The outer panel shall be constructed of G90 galvanized 18-gauge steel.
- D. Inspection and Access Panels and Access Doors:
  - 1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
  - 2. Inspection and Access Panels:
    - a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
    - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
  - 3. Access Doors:
    - a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
    - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - c. Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
  - 4. Locations and Applications:
    - a. Fan Section: Doors and inspection and access panels.
    - b. Access Section: Doors.
    - c. Coil Section: Inspection and access panel.
    - d. Damper Section: Doors.
    - e. Filter Section: Doors large enough to allow periodic removal and installation of filters.

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- f. Mixing Section: Doors.
- g. Humidifier Section: Doors.

## **2.4 FAN, DRIVE, AND MOTOR SECTION**

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
  - 1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
    - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- B. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
- C. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- D. Fan Shaft Bearings:
  - 1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.
- E. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2 inch.
- F. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."
  - 1. Enclosure Type: Totally enclosed, fan cooled.
  - 2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

## **2.5 HOT WATER HEATING COILS**

- A. Primary surface shall be round seamless 5/8 inch O.D. by 0.035-inch thick copper tube on 1.5-inch centers, staggered in the direction of airflow. All joints shall be brazed.
- B. Secondary surface - Secondary surface shall consist of 0.0095 inch rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a

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continuous surface cover over the entire tube for maximum heat transfer. Bare copper tube shall not be visible between fins and the fins shall have no openings punched in them to accumulate lint and dirt. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.

- C. Casings - Casings shall be constructed of continuous galvanized steel with 3/8" diameter bolt holes for mounting on 6" centers. Coil side plates shall also be of continuous galvanized steel of reinforced flange type for greater strength and ease of stacking coils in banks. Coils shall be individually removable without disturbing the other coils and removed through the coil pull panel. Even though all piping will need to be disconnected.
- D. Coils - Coils shall have equal pressure drop through all circuits. Coils shall be circuited for counter flow heat transfer to provide the maximum mean effective temperature difference for maximum heat transfer rates. The use of internal restrictive devices to obtain turbulent flow will not be acceptable as they prevent complete drawing of the coil and give high water pressure drop. All coils exceeding 45" FL shall be furnished with four fin angles to properly position the coil core.
- E. Water Headers - Headers on coils shall be of non-ferrous materials using seamless copper tubing. The headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility. Vent connections shall be provided at the highest point to assure proper venting.
  - 1. Connections - The heating water coil connection will be a copper sweat or carbon steel male pipe thread type.
  - 2. Tests - The complete coil core shall be tested with 315 psig air pressure under warm water and be suitable for operation at 250 psig working pressures. Individual tube tests and core tests before installation of headers shall not be considered satisfactory. Water-cooling coils shall be circuited for drainability. Use of internal restrictive devices to obtain turbulent flow shall not be acceptable. Vents and drains shall be furnished on all water coils. Coils shall be rated in accordance with ARI.
- F. Installation - Coils shall be mounted in galvanized holding racks. Water coil supply and return connections shall be extended to the unit exterior. Water coil drain and vent connections are accessible from the interior of the unit and are not extended. Cooling coils shall be mounted in an insulated pitched 304 stainless steel condensate pan.

## **2.6 CHILLED WATER COILS**

- A. Primary surface shall be round seamless 5/8 inch O.D. by 0.035-inch thick copper tube on 1.5-inch centers, staggered in the direction of airflow. All joints shall be brazed.
- B. Secondary surface - Secondary surface shall consist of 0.0095 inch rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Bare copper tube shall not be visible between fins and the fins shall have no openings punched in them to accumulate lint and dirt. Tubes shall be mechanically expanded into the fins to provide a

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continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.

- C. Casings - Casings shall be constructed of continuous stainless steel with 3/8" diameter bolt holes for mounting on 6" centers. Coil side plates shall also be of continuous stainless steel of reinforced flange type for greater strength and ease of stacking coils in banks. Coils shall be individually removable without disturbing the other coils and removed through the coil pull panel. Even though all piping will need to be disconnected.
- D. Coils - Coils shall have equal pressure drop through all circuits. Coils shall be circuited for counter flow heat transfer to provide the maximum mean effective temperature difference for maximum heat transfer rates. The use of internal restrictive devices to obtain turbulent flow will not be acceptable as they prevent complete drawing of the coil and give high water pressure drop. All coils exceeding 45" FL shall be furnished with four fin angles to properly position the coil core.
- E. Water Headers - Headers on coils shall be of non-ferrous materials using seamless copper tubing. The headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility. Vent connections shall be provided at the highest point to assure proper venting.
  - 1. Connections - The chilled water coil connection will be a copper sweat or carbon steel male pipe thread type.
  - 2. Tests - The complete coil core shall be tested with 315 psig air pressure under warm water and be suitable for operation at 250 psig working pressures. Individual tube tests and core tests before installation of headers shall not be considered satisfactory. Water-cooling coils shall be circuited for drainability. Use of internal restrictive devices to obtain turbulent flow shall not be acceptable. Vents and drains shall be furnished on all water coils. Coils shall be rated in accordance with ARI.
- F. Installation - Coils shall be mounted in stainless holding racks. Water coil supply and return connections shall be extended to the unit exterior. Water coil drain and vent connections are accessible from the interior of the unit and are not extended. Cooling coils shall be mounted in an insulated pitched 304 stainless steel condensate pan.
- G. Drain Pan – IAQ stainless steel drain pan sloping in two directions with intermediate drain pans serving each coil section.

## 2.7 REFRIGERANT COILS

- 1. Tubes: Copper.
- 2. Fins:
  - a. Material: Aluminum.
  - b. Fin Spacing: Maximum 12 fins per inch.
- 3. Fin and Tube Joints: Mechanical bond.
- 4. Headers: [Seamless-copper headers with brazed connections] <Insert material and connections>.
- 5. Frames: [Galvanized steel] [Stainless steel] <Insert material frame>.
- 6. Coatings: [None] [Corrosion-resistant coating].

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7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
  - a. Working Pressure: Minimum 300 psig.

## **2.8 AIR FILTRATION SECTION**

- A. Filters shall be Farr type MERV 8 or approved equal. Air filters shall be 2" thick, pleated, disposable type. Each filter shall consist of a non-woven cotton and synthetic fabric media; media support grid and enclosing frame. The filter media shall have an efficiency of MERV 8 on ASHRAE Test Standard. The filter shall be listed by UL as Class 2. A bank of galvanized universal front loading holding frames shall be arranged for upstream access. Provisions shall be made on the downstream side of the frames to prevent filter blowout from moisture or overloading. Filter pressure indicators shall be on every bank and shall be Dwyer Photohelic to provide signal to BAS.

## **2.9 DAMPERS**

- A. Damper shall have 2-position electric actuators with an integral limit switch. The limit switch shall be wired through the exhaust fan (or supply fan) coil.
- B. Frame – Flanged, 5 inches x 1" x 6063T5 extruded aluminum hat channel with minimum .125 wall thickness (127x25x3.2). Low profile, 5" x 1/2" (127x13) top and bottom frames on dampers 12" (305) high and less. Mounting flanges on both sides of frame.
- C. Blades – 6" (152) wide, 6063T5 heavy gauge extruded aluminum, airfoil shape and shall be horizontal blades with parallel blade action.
- D. Bearings - Molded synthetic sleeve, turning in extruded hole in frame.
- E. Blade and Jam Seals – Blades shall have Ruskiprene blade edge seals mechanically attached to blade edge. Jam seals shall be flexible metal compression type.
- F. Linkage - Concealed in frame.
- G. Axles - minimum 1/2-inch (13 mm) diameter plated steel, hex-shaped, mechanically attached to blade.
- H. Mounting – Vertical
- I. Finish - aluminum
- J. Performance – Damper shall be able to withstand -72 to 275 degrees F (-58 to 135 degrees C). Capacity of damper is Class 1A leakage.

## **2.10 AIR-TO-AIR ENERGY RECOVERY**

- A. Heat Wheels:

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1. Casing:
  - a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
  - b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
  - c. Casing seals on periphery of rotor, on duct divider, and on purge section.
  - d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
2. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
3. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 400,000 hours.
4. Controls:
  - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
  - b. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
  - c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
  - d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
  - e. Pilot-Light Indicator: Display rotor rotation and speed.
  - f. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

## **2.11 AIR BLENDER**

- A. Description: Static air mixer device to provide mixing of two airstreams to within plus/minus 6 deg F.
- B. Material: Galvanized steel.
- C. Coating: None.

## **2.12 ELECTRICAL**

- A. Unit shall require a single point electrical connection at the main electrical panel. The electrical panel shall be NEMA 3R rated and mounted on the unit exterior. The electric panel shall consist of a non-fused disconnect, fused inverters, NEMA full voltage starters for each fan and variable speed wheel, control power transformer, and HOA switch for the unit. Electrical panels shall bear an ETL label.
- B. All wiring 120 volt and higher and wire size #8 and smaller shall be run in MC cable. All wire size #6 and larger shall be run in EMT. Fan motors requiring wire run in EMT shall have a 2' length of sealtight at the motor junction box. Low voltage wiring shall use plenum cable,

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installed external to the conduit. Starter coils shall be 24 volt AC for contactors rated 65 amps or less and 120 volt AC for contactors rated greater than 65 amps.

**2.13 CONTROL HARDWARE**

- A. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

**2.14 LIGHTS & GFI RECEPTACLE**

- A. Vapor tight LED lights shall be provided in access compartments as shown on the General Arrangement drawing. Lights shall be wired to a single switch on the unit exterior. A GFI receptacle shall be mounted next to the light switch. A separate 120-volt power connection shall not be required to provide power to the lights and receptacle. Lights and GFI will be wired line side of the main unit disconnect with its own fused disconnect and step down transformer to provide 120-volt power.

**2.15 SOURCE QUALITY CONTROL**

- A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
- C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Equipment Mounting:
  - 1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

### **3.3 PIPING CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.



### **3.4 ELECTRICAL CONNECTIONS**

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
  - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

### **3.5 CONTROL CONNECTIONS**

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

### **3.6 FIELD QUALITY CONTROL**

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
  - 2. Charge refrigerant coils with refrigerant and test for leaks.
  - 3. Fan 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.

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- E. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- F. Prepare test and inspection reports.

### **3.7 STARTUP SERVICE**

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Verify that shipping, blocking, and bracing are removed.
  - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
  - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
  - 6. Verify that zone dampers fully open and close for each zone.
  - 7. Verify that face-and-bypass dampers provide full face flow.
  - 8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
  - 9. Comb coil fins for parallel orientation.
  - 10. Verify that proper thermal-overload protection is installed for electric coils.
  - 11. Install new, clean filters.
  - 12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
  - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
  - 2. Measure and record motor electrical values for voltage and amperage.
  - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

### **3.8 ADJUSTING**

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

### **3.9 CLEANING**

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- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

**3.10 DEMONSTRATION**

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

**END OF SECTION 23 7313.16**



**SECTION 23 7416.13**

**PACKAGED, LARGE-CAPACITY, 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.

**1.2 SUMMARY**

- A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components and accessories:
  - 1. Casings.
  - 2. Fans.
  - 3. Motors.
  - 4. Coils.
  - 5. Refrigerant circuit components.
  - 6. Air filtration.
  - 7. Dampers.
  - 8. Electrical power connections.
  - 9. Controls.
  - 10. Accessories
  - 11. Roof curbs.

**1.3 DEFINITIONS**

- A. DDC: Direct-digital controls.
- B. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- D. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating

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operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

#### **1.4 ACTION SUBMITTALS**

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
  - 1. Factory selection calculations for each antimicrobial ultraviolet lamp installation.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

#### **1.5 INFORMATIONAL 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. Roof curbs and flashing.

#### **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

#### **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set(s) of filters for each unit.

#### **1.8 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 years from date of Substantial Completion.
  - 2. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.

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3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 SYSTEM DESCRIPTION**

- 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.

### **2.2 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Trane.
  2. Daikin Applied.
  3. JCI/York.
  4. Carrier.

## **2.3 CASINGS**

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Double-Wall Construction: Fill space between walls with 2 inch foam insulation and seal moisture tight for R-13 performance.
- C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
- D. Inner Casing Fabrication Requirements:
  - 1. Inside Casing: G-90-coated galvanized steel, 0.034 inch thick.
- E. Condensate Drain Pans: Fabricated using stainless 0.025 inch thick steel sheet, a minimum of 2 inches deep, and complying with ASHRAE 62.1 for design and construction of drain pans.
  - 1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
  - 2. Drain Connections: Threaded nipple.
- F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

## **2.4 FANS**

- A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.
  - 1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
- B. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multi-speed motors.
- C. Relief-Air Fan: Forward curved, shaft mounted on permanently lubricated motor.

## **2.5 MOTORS**

- A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.
- B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- C. Service Factor: 1.15.



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- D. Efficiency: Premium efficient.
- E. NEMA Design: B.

## **2.6 COILS**

### **A. Supply-Air Refrigerant Coil:**

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

### **B. Outdoor-Air Refrigerant Coil:**

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

### **C. Hot-Gas Reheat Refrigerant Coil:**

1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Suction-discharge bypass valve.

## **2.7 REFRIGERANT CIRCUIT COMPONENTS**

### **A. Number of Refrigerant Circuits: Two.**

### **B. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief.**

### **C. Refrigeration Specialties:**

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.

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7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.

## **2.8 AIR FILTRATION**

- A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2.
- B. Pleated Panel Filters:
  1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
  2. Filter Unit Class: UL 900, Class 1.
  3. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
    - a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
    - b. Adhesive: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
    - c. Media shall be coated with an antimicrobial agent.
    - d. Separators shall be bonded to the media to maintain pleat configuration.
    - e. Welded-wire grid shall be on downstream side to maintain pleat.
    - f. Media shall be bonded to frame to prevent air bypass.
    - g. Support members on upstream and downstream sides to maintain pleat spacing.

## **2.9 DAMPERS**

- A. Outdoor- and Return-Air Mixing Dampers: Parallel-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.
  1. Leakage Rate: As required by ASHRAE/IES 90.1.
  2. Damper Motor: Modulating with adjustable minimum position.
  3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1, with bird screen and hood.

## **2.10 ELECTRICAL POWER CONNECTIONS**

- A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

## 2.11 CONTROLS

### A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:
  - a. Heat-cool-off switch.
  - b. Fan on-auto switch.
  - c. Fan-speed switch.
  - d. Automatic changeover.
  - e. Adjustable deadband.
  - f. Exposed set point.
  - g. Exposed indication.
  - h. Degree F indication.
  - i. Unoccupied-period-override push button.
  - j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.
3. Wall-mounted humidistat or sensor with the following features:
  - a. Exposed set point.
  - b. Exposed indication.

### B. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:
  - a. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.
  - b. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
3. Scheduled Operation: Occupied and unoccupied periods on seven 365-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:
  - a. Heating Setback: Plus 10 deg F.
  - b. Cooling Setback: System off.
  - c. Override Operation: Two hours.
5. Supply Fan Operation:
  - a. Occupied Periods: Run fan continuously.
  - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
6. Refrigerant Circuit Operation:

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- a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
  - b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
- 7. Hot-Gas Reheat-Coil Operation:
  - a. Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
  - b. Unoccupied Periods: Reheat not required.
- 8. Fixed Minimum Outdoor-Air Damper Operation:
  - a. Occupied Periods: Open to 25 percent.
  - b. Unoccupied Periods: Close the outdoor-air damper.
- 9. Economizer Outdoor-Air Damper Operation:
  - a. Morning warm up and cool down cycles.
  - b. Occupied Periods: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F. Use mixed-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
  - c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- 10. Carbon Dioxide Sensor Operation:
  - a. Occupied Periods: Reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 1000-ppm concentration.
  - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

C. Interface Requirements for HVAC Instrumentation and Control System:

- 1. Interface relay for scheduled operation.
- 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
- 3. Provide BACnet compatible interface for central HVAC control workstation for the following:
  - a. Adjusting set points.
  - b. Monitoring supply fan start, stop, and operation.
  - c. Inquiring data to include supply- and room-air temperature and humidity.
  - d. Monitoring occupied and unoccupied operations.
  - e. Monitoring constant and variable motor loads.
  - f. Monitoring variable-frequency drive operation.
  - g. Monitoring cooling load.

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- h. Monitoring economizer cycles.
- i. Monitoring air-distribution static pressure and ventilation air volume.

## **2.12 ACCESSORIES**

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- C. Remote potentiometer to adjust minimum economizer damper position.
- D. Return-air bypass damper.
- E. Factory- or field-installed demand-controlled ventilation.
- F. Safeties:
  - 1. Condensate overflow switch.
  - 2. Phase-loss reversal protection.
  - 3. High and low pressure control.
- G. Hail guards of galvanized steel, painted to match casing.
- H. Door switches to disable heating or reset set point when open.
- I. Outdoor air intake weather hood.

## **2.13 ROOF CURBS**

- A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
  - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
    - a. Materials: ASTM C 1071, Type I or II.
    - b. Thickness: 1-1/2 inches.
  - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    - a. Liner Adhesive: Comply with ASTM C 916, Type I.
    - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

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- d. Liner Adhesive: Comply with ASTM C 916, Type I.
- B. Curb Dimensions: Height of 36 inches.

### **PART 3 - EXECUTION**

#### **3.1 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.

#### **3.2 INSTALLATION**

- A. Roof Curb: Install on roof structure or concrete base, 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 Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

#### **3.3 CONNECTIONS**

- A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- B. 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 233300 "Air Duct Accessories."
  - 4. Install return-air duct continuously through roof structure.
- C. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

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- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
  - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
  - 3. Locate nameplate where easily visible.

### **3.4 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 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. RTU will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.5 STARTUP SERVICE**

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

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11. Connect and purge gas line.
12. Remove packing from vibration isolators.
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 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. 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.
21. Calibrate thermostats.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg 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.
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.



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- b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
- 28. Verify operation of remote panel including pilot-light operation and 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-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.

**3.6 CLEANING AND ADJUSTING**

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

**3.7 DEMONSTRATION**

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

**END OF SECTION 23 7416.13**



**SECTION 23 8216.11**

**HYDRONIC AIR COILS**

**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 hydronic heating and cooling air coils.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
  - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

**PART 2 - PRODUCTS**

**2.1 DESCRIPTION**

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

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## **2.2 COILS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Aerofin.
  - 2. Coil Company, LLC.
  - 3. Colmac Coil Manufacturing, Inc.
  - 4. Greenheck Fan Corporation.
  - 5. Heatcraft Worldwide Refrigeration.
  - 6. RAE Coils; a division of RAE Corporation.
  - 7. Daikin-McQuay
  - 8. JCI/York
  - 9. Aeon
- B. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.
- D. Source Quality Control: Factory tested to 300 psig.
- E. Tubes: ASTM B 743 copper, minimum 0.035 inch thick.
- F. Fins: Aluminum, minimum 0.010 inch thick.
- G. Headers: Seamless copper tube with brazed joints, prime coated.
- H. Frames: Galvanized-steel channel frame, minimum 0.064 inch thick for flanged mounting.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install coils level and plumb.

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- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install stainless-steel drain pan under each cooling coil.
  - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
  - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
  - 3. Extend drain pan upstream and downstream from coil face.
  - 4. Extend drain pan under coil headers and exposed supply piping.
- D. Straighten bent fins on air coils.
- E. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

**END OF SECTION 23 8216.11**



**SECTION 23 8216.13**  
**REFRIGERANT AIR COILS**

**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. Refrigerant air coils.
- B. Related Requirements:
  - 1. Section 238216.11 "Hydronic Air Coils" for air coils using water as the heating or cooling medium.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
  - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

**1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

**1.6 FIELD CONDITIONS**

- A. Altitude above Mean Sea Level: 1,000 feet.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: 200 psig/300 deg F.
- D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.

### **2.2 REFRIGERANT AIR COILS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Aerofin.
  - 2. Carrier Global Corporation.
  - 3. Greenheck Fan Corporation.
  - 4. Heatcraft.
  - 5. Trane.
  - 6. USA Coil & Air.
- B. Source Limitations: Obtain refrigerant coils from single source from single manufacturer.
- C. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into plate fins. Coils are to be counterflow circuited and equipped with pressure-type distributors, and distributor tubes are to be of equal length, to ensure equal distribution of refrigerant to each circuit.
- D. Circuiting: Interlaced and face control.
- E. Tubes:
  - 1. Material: Copper.
  - 2. Nominal Diameter: Selected for performance indicated.
  - 3. Nominal Wall Thickness: As required by performance, minimum of 0.020 inch (0.5 mm) thick.
  - 4. Return Bends: 180-degree bends; material, wall thickness, and nominal diameter to match tubes.
  - 5. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
- F. Fins:
  - 1. Type: Plate.
  - 2. Materials:



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- a. Aluminum: 0.0075 inch thick.
  3. Spacing: Maximum 12 fins per inch.
  4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
  5. Configuration: Wave, corrugated, or waffle-face fins.
  6. Fin and Tube Joint: Silver brazed.
- G. Headers:
1. Material: Seamless copper.
  2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
  3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
  4. Protect openings to prevent entry of dirt into coil.
- H. Casings and Tube Sheets:
1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
  2. Materials:
    - a. Stainless steel, Type 304, No. 2D finish.
    - b. Galvanized steel, G90 coating.
    - c. Copper.
    - d. Aluminum.
  3. Top and Bottom Casings:
    - a. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
    - b. Thickness: Minimum of 16 gauge thick.
  4. End Tube Sheets:
    - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
    - b. Flange face minimum of 1-1/2 inches.
    - c. Thickness: Minimum of 16 gauge thick.
  5. Intermediate Tube Sheets:
    - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
    - b. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
    - c. Flange face minimum of 1/2 inch.
    - d. Thickness: Minimum of 16 gauge thick.
- I. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

- J. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.
- K. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
  - 1. Manufacturer name, address, telephone number, and website address.
  - 2. Manufacturer model number.
  - 3. Serial number.
  - 4. Manufacturing date.
  - 5. Coil identification (indicated on Drawings).
  - 6. Coil fin length.
  - 7. Coil fin height.
  - 8. Coil weight with fluid/without fluid.
  - 9. Coil casing material and thickness.
  - 10. Coil fin material and thickness.
  - 11. Coil tube material and thickness.
  - 12. Coil header material and thickness.
- L. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
- M. Coating: None.

## **2.3 MATERIALS**

- A. Aluminum: ASTM B209.
- B. Copper Sheet: ASTM B152.
- C. Copper Tube: ASTM B75/75M annealed temper or ASTM B280 drawn temper.
- D. Galvanized Steel: ASTM A653/A653M.
- E. Stainless Steel: ASTM A240/A240M.
- F. Steel: ASTM A53/A53M.

## **2.4 SOURCE QUALITY CONTROL**

- A. Refrigerant Coils: Factory tested using dry nitrogen while coil is completely submerged underwater to design pressure indicated, but not less than 400-psig internal pressure.
- B. Coils to display a tag with inspector's identification as proof of testing.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install stainless steel drain pan under each cooling coil.
  - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
  - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
  - 3. Extend drain pan upstream and downstream from coil face.
  - 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

#### **3.3 PIPING CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

**END OF SECTION 23 8216.13**



**SECTION 23 8219**

**FAN COIL 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.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Ductless fan coil units and accessories.
  - 2. Ducted fan coil units and accessories.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

## **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fan Coil Unit Filters: Furnish one (1) spare filters for each filter installed.

## **1.6 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## **1.7 COORDINATION**

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

## **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. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

### **2.2 DUCTLESS FAN COIL UNITS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Daikin Applied.
  - 2. ENVIRO-TEC; by Johnson Controls, Inc.
  - 3. Greenheck Fan Corporation.
  - 4. IEC (International Environmental Corporation); LSB Industries.
  - 5. Titus.

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6. York/JCI.
  7. Carrier.
  8. Trane.
- B. Fan Coil Unit Configurations: Row split.
1. Number of Heating Coils: One with two-pipe system.
  2. Number of Cooling Coils: One with two and/or four-pipe system.
- C. Coil Section Insulation: 1-inch- thick, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
  2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.
1. Horizontal Units Only - Provide factory installed and wired drain pan safety switch to shut down unit in the event of drain pan overflow.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- F. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color as selected by Architect.
1. Vertical Unit Front Panels: Removable, steel, with integral stamped steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
  2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped discharge grilles.
  3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard colors. Return grille shall provide maintenance access to fan coil unit.
  4. Steel recessing flanges for recessing fan coil units into ceiling or wall.
- G. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
1. Louver Configuration: Horizontal, rain-resistant louver. Louver shall be removable from frame.
  2. Louver Material: Aluminum.
  3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
  4. Decorative Grille: On outside of intake.
  5. Finish: Baked enamel, color as selected by Architect from manufacturer's standard colors.
- H. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic, modulating actuators.

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- I. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
  - 1. 1" Thick Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.
- J. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- K. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- L. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 3. Wiring Termination: Connect motor to chassis wiring with plug connection.
- M. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- N. Electrical Connection: Factory wire motors and controls for a single electrical connection with factory installed disconnect switch.

## **2.3 DUCTED FAN COIL UNITS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Daikin Applied.
  - 2. ENVIRO-TEC; by Johnson Controls, Inc.
  - 3. Greenheck Fan Corporation.
  - 4. Titus.
  - 5. York/JCI.
  - 6. Aeon.
  - 7. IEC International Environmental.
- B. Fan Coil Unit Configurations: Row split.
  - 1. Number of Heating Coils: One with two-pipe system.
  - 2. Number of Cooling Coils: One with four-pipe system.
- C. Coil Section Insulation: 1-inch- thick, closed cell complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.



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1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
  2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1.
1. Horizontal Units Only - Provide factory installed and wired drain pan safety switch to shut down unit in the event of drain pan overflow.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
  2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
  3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
  4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
- G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- H. MERV Rating: 7 when tested according to ASHRAE 52.2.
1. 1" Thick Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.
- I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- J. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.
- K. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
- L. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."

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- M. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- N. Electrical Connection: Factory wire motors and controls for a single electrical connection with factory installed disconnect switch.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers.
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

#### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
  - 3. Connect condensate drain to indirect waste.
    - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

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- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

### **3.5 ADJUSTING**

- A. Adjust initial temperature and humidity set points.
- B. 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 up to two visits to Project during other-than-normal occupancy hours for this purpose.

### **3.6 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

**END OF SECTION 23 8219**



**SECTION 23 8223**

**UNIT VENTILATORS**

**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 unit ventilators and accessories with the following heating and cooling features:
  - 1. Direct-expansion refrigerant cooling coil with hydronic reheat coil.
  - 2. Two pipe hydronic coil for heating and cooling.
  - 3. Four pipe hydronic system with hydronic heating coil and hydronic cooling coil

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Detail anchorages and attachments to structure and to supported equipment.
  - 4. Include diagrams for power, signal, and control wiring.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For unit ventilators to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

## **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Unit Ventilator Filters: Furnish one (1) spare filter(s) for each filter installed.

## **1.6 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## **1.7 COORDINATION**

- A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

## **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. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

### **2.2 MANUFACTURERS**

- A. Daikin-McQuay
- B. JCI/York
- C. Magic-Aire
- D. Trane

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- E. Carrier

## **2.3 MANUFACTURED UNITS**

- A. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow- or draw-through configuration, and hydronic cooling coil.
  - 1. Unit Ventilator Coil Configurations: Row split.
    - a. Unit with Hydronic Heating/Cooling: One hydronic coil two-pipe system.
    - b. Unit with DX Cooling and Hydronic Heating: One hydronic coil in reheat position and one DX cooling coil.
    - c. Unit with Hydronic Cooling and Hydronic Heating: One hydronic coil in reheat position and one hydronic cooling coil.

## **2.4 CABINETS**

- A. Insulation: Minimum 1-inch- thick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
  - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."
  - 1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
  - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Main and Auxiliary Drain Pans: Insulated galvanized steel with plastic liner, formed as required by ASHRAE 62.1. Drain pans shall be removable.
  - 1. Horizontal Units Only - Provide factory installed and wired drain pan safety switch to shut down unit in the event of drain pan overflow.
- D. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.
  - 1. Steel components exposed to moisture shall be baked-enamel finished.
- E. Cabinet Finish: Baked enamel, in manufacturer's standard color as selected by Architect.
- F. Indoor-Supply-Air Grille: adjustable linear bar.

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- G. Return-Air Inlet: Front toe space and/or Back inlet with top inlet grille.
- H. End Panels: Matching material and finish of unit ventilator.
- I. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
  - 1. Louver Configuration: Horizontal, rain-resistant louver. Louver must be removable from frame.
  - 2. Louver Material: Aluminum.
  - 3. Bird Screen: 1/2-inch mesh screen on interior side of louver.
  - 4. Decorative Grille: On outside of intake.
  - 5. Finish: Baked enamel, color as selected by Architect from manufacturer's standard colors.

## 2.5 COILS

- A. Test and rate unit ventilator coils according to ASHRAE 33.
- B. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
- C. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig for a minimum 300-psig working pressure. Include thermal expansion valve.

## 2.6 INDOOR FAN

- A. Fan and Motor Board: PSC – 3-Speed (ECM Motors are only acceptable on horizontal ducted units.)
  - 1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Fan Shaft and Bearings: Hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
  - 3. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 4. Wiring Termination: Connect motor to chassis wiring with plug connection.

## 2.7 DAMPERS

- A. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.



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- B. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric actuator.
- C. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; with factory-mounted electric actuator.
- D. Comply with ASHRAE/IES 90.1.

## **2.8 ACCESSORIES**

- A. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
- B. Insulated false back with gasket seals on wall and outdoor-air plenum.
  - 1. Insulation: Minimum 1-inch- thick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
    - a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84 by a qualified testing agency.
    - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Return-air plenum, 6 inches thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
- D. Duct flanges for supply-, return-, and outdoor-air connections.
- E. Radiation Grille: Linear-bar grille with finish to match discharge-air grille.
- F. Filters:
  - 1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
  - 2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
  - 3. Material: 1" thick pleated cotton-polyester media, MERV 7.

## **2.9 BASIC UNIT CONTROLS**

- A. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Electrical Connection: Factory wire motors and controls for a single electrical connection with factory installed disconnect switch.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas, with Installer present, to receive unit ventilators for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install unit ventilators to comply with NFPA 90A.
- B. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 1.0-inch static-deflection spring hangers.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.
- D. Comply with requirements in Section 236200 "Packaged Compressor and Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
  - 3. Connect condensate drain to indirect waste.
- B. Install refrigerant piping as required by Section 232300 "Refrigerant Piping," and add refrigerant as required to compensate for length of piping.
- C. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

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- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
  - 4. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F higher, or 20 deg F lower, than room temperature.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

### **3.5 ADJUSTING**

- A. Adjust initial temperature and humidity set points.
- B. 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 up to two visits to Project during other-than-normal occupancy hours for this purpose.

### **3.6 DEMONSTRATION**

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

**END OF SECTION 23 8223**



## **SECTION 23 8233**

### **CONVECTORS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

##### **1.2 SUMMARY**

- A. Section includes hydronic convectors.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include details and dimensions of custom-fabricated enclosures.
  - 4. Indicate location and size of each field connection.
  - 5. Indicate location and arrangement of piping valves and specialties.
  - 6. Indicate location and arrangement of integral controls.
  - 7. Include enclosure joints, corner pieces, access doors, and other accessories.
  - 8. Include diagrams for power, signal, and control wiring.

#### **PART 2 - PRODUCTS**

##### **2.1 HOT-WATER CONVECTORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Engineered Air.
  - 2. Slant/Fin Corp.
  - 3. Sterling HVAC Products; a Mestek company.
  - 4. Trane.

- B. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig.
- C. Front and Top Panel: Minimum 0.0528-inch- thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
- D. Wall-Mounted Back and End Panels: Minimum 0.0428-inch-thick steel.
- E. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- F. Insulation: 1/2-inch-thick, fibrous glass on inside of the back of the enclosure.
- G. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
- H. Damper: Knob-operated internal damper.
- I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- J. Enclosure Style: Flat top.
  - 1. Front Inlet Grille: Punched louver; painted to match enclosure.
  - 2. Front Outlet Grille: Punched louver; painted to match enclosure.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas to receive convectors for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of convector.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Install convectors level and plumb.
- B. Install valves within reach of access door provided in enclosure.
- C. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- D. Install piping within pedestals for freestanding units.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water convectors and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
  - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install control valves as required by Section 230923.11 "Control Valves."
- D. Install piping adjacent to convectors to allow service and maintenance.
- E. Ground electric convectors according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following field tests and inspections:
  - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test: After electrical circuitry has been energized, start convectors to confirm proper operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Convectors will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

**END OF SECTION 23 8233**





**SECTION 23 8236**

**FINNED-TUBE RADIATION HEATERS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section includes hydronic finned-tube radiation heaters.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include details and dimensions of custom-fabricated enclosures.
  - 4. Indicate location and size of each field connection.
  - 5. Indicate location and arrangement of piping valves and specialties.
  - 6. Indicate location and arrangement of integral controls.
  - 7. Include enclosure joints, corner pieces, access doors, and other accessories.
  - 8. Include diagrams for power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.
- D. Color Samples for Initial Selection: For finned-tube radiation heaters with factory-applied color finishes.
- E. Color Samples for Verification: For each type of exposed finish.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor 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, including wall construction, to which finned-tube radiation heaters will be attached.
  - 2. Method of attaching finned-tube radiation heaters to building structure.
  - 3. Penetrations of fire-rated wall and floor assemblies.
- B. Field quality-control reports.

### **PART 2 - PRODUCTS**

#### **2.1 HOT-WATER FINNED-TUBE RADIATION HEATERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Embassy Industries, Inc.
  - 2. Engineered Air.
  - 3. Hydro-Air Components Inc.
  - 4. Sterling.
  - 5. Rosemex Products.
  - 6. Slant/Fin Corp.
  - 7. Sigma Corp.
  - 8. Modine
  - 9. Vulcan
- B. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
- C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.
  - 1. Tube Diameter: NPS 1.
  - 2. Fin Size: 4 by 4 inches.
  - 3. Fin Spacing: 58 per foot.
- D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
- E. Rust-Resistant Front Panel: Minimum 0.064-inch- thick, ASTM A 653/A 653M, G60 galvanized steel.

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- F. Wall-Mounted Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.
- G. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.
- H. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- I. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
- J. Damper: Knob-operated internal damper at enclosure outlet.
- K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- L. Enclosure Style: Flat top.
  - 1. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - a. Mill-finish aluminum.
    - b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
    - c. Painted to match enclosure.
  - 2. Top Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - a. Mill-finish aluminum.
    - b. Anodized finish, color as selected by Architect from manufacturer's standard colors.
    - c. Painted to match enclosure.
  - 3. Enclosure Height: Refer to equipment schedules.
  - 4. Enclosure Depth: Refer to equipment schedules.
- M. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas to receive finned-tube radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hydronic-piping and electrical connections to verify actual locations before installation of finned-tube radiation heaters.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 FINNED-TUBE RADIATION HEATER INSTALLATION**

- A. Install units level and plumb.
- B. Install enclosure continuously around corners, using outside and inside corner fittings.
- C. Join sections with splice plates and filler pieces to provide continuous enclosure.
- D. Install access doors for access to valves.
- E. Install enclosure continuously from wall to wall.
- F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
- G. Install valves within reach of access door provided in enclosure.
- H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.
- I. Install piping within pedestals for freestanding units.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water finned-tube radiation heaters and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
  - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Install control valves as required by Section 230923.11 "Control Valves."
- D. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.
- E. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following field tests and inspections:

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1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
  3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

**END OF SECTION 23 8236**



**SECTION 23 8239.13**

**CABINET UNIT HEATERS**

**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 cabinet unit heaters with centrifugal fans hot-water coils.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include location and size of each field connection.
  - 4. Include details of anchorages and attachments to structure and to supported equipment.
  - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
  - 6. Indicate location and arrangement of piping valves and specialties.
  - 7. Indicate location and arrangement of integral controls.
  - 8. Wiring Diagrams: Power, signal, and control wiring.

## **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

## **1.6 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Berko; Marley Engineered Products.
  - 2. Carrier Corporation; a unit of United Technologies Corp.
  - 3. Chromalox, Inc.
  - 4. Dunham-Bush.
  - 5. Markel Products; TPI Corporation.
  - 6. Marley Engineered Products.
  - 7. QMark; Marley Engineered Products.
  - 8. Sigma Corp.
  - 9. Sterling
  - 10. Modine
  - 11. Daikin Applied
  - 12. Zehnder-Rittling
  - 13. Vulcan

### **2.2 DESCRIPTION**

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 2021.



## **2.3 COIL SECTION INSULATION**

- A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.
  - 1. Thickness: 1 inch.
  - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
  - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
  - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

## **2.4 CABINETS**

- A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
  - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch- thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
  - 2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch- thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
  - 3. Recessed Flanges: Steel, finished to match cabinet.
  - 4. Control Access Door: Key operated.
  - 5. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.
  - 6. Extended Piping Compartment: 8-inch- wide piping end pocket.
  - 7. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.

## **2.5 FILTERS**

- A. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
- B. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
- C. Material: 1" Thick pleated cotton-polyester media, MERV 8.

## **2.6 COILS**

- A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

## **2.7 CONTROLS**

- A. Fan and Motor Board: Removable.
  - 1. Fan: Forward curved, high static, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- C. Electrical Connection: Factory-wired motors and controls for a single field connection with factory disconnect switch.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with elastomeric hangers.
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," Section 232213 "Steam and Condensate Heating Piping," and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
- E. Comply with safety requirements in UL 1995.
- F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of cabinet unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Heating Piping Specialties."
- H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

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**3.5 ADJUSTING**

- A. Adjust initial temperature set points.
- B. 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 up to two visits to Project during other-than-normal occupancy hours for this purpose.

**3.6 DEMONSTRATION**

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

**END OF SECTION 23 8239.13**

**SECTION 23 8239.16**

**PROPELLER UNIT HEATERS**

**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 propeller unit heaters with hot-water coils.

**1.3 DEFINITIONS**

- A. CWP: Cold working pressure.
- B. PTFE: Polytetrafluoroethylene plastic.
- C. TFE: Tetrafluoroethylene plastic.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, and details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include location and size of each field connection.
  - 4. Include details of anchorages and attachments to structure and to supported equipment.
  - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
  - 6. Indicate location and arrangement of piping valves and specialties.
  - 7. Indicate location and arrangement of integral controls.
  - 8. Wiring Diagrams: Power, signal, and control wiring.

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**1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Airtherm; a Mestek company.
  - 2. CCI Thermal Technologies, Inc.
  - 3. Engineered Air.
  - 4. Rosemex Products.
  - 5. Sigma Corp.
  - 6. Daikin Applied.
  - 7. Modine
  - 8. Vulcan
  - 9. Sterling

**2.2 DESCRIPTION**

- A. Assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with UL 2021.
- D. Comply with UL 823.

**2.3 HOUSINGS**

- A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

## **2.4 COILS**

- A. General Coil Requirements: Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.
- B. Hot-Water Coil: Cupronickel tube, minimum 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 400 psig and a maximum entering-water temperature of 450 deg F, with manual air vent. Test for leaks to 600 psig underwater.

## **2.5 FAN AND MOTOR**

- A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- B. Motor: Permanently lubricated, variable speed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

## **2.6 CONTROLS**

- A. Control Devices:
  - 1. Wall-mounted, variable fan-speed switch.

# **PART 3 - EXECUTION**

## **3.1 EXAMINATION**

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## **3.2 INSTALLATION**

- A. Install propeller unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

### **3.3 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
  - 1. Section 232113 "Hydronic Piping."
  - 2. Section 232116 "Hydronic Piping Specialties."
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- F. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of propeller unit heater. Steam specialties are specified in Section 232216 "Steam and Condensate Piping Specialties."
- G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.



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- C. Prepare test and inspection reports.

**3.5 ADJUSTING**

- A. Adjust initial temperature set points.
- B. 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 up to two visits to Project during other-than-normal occupancy hours for this purpose.

**3.6 DEMONSTRATION**

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

**END OF SECTION 23 8239.16**



**SECTION 23 8416.16**

**INDOOR, MECHANICAL DEHUMIDIFICATION 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.

**1.2 SUMMARY**

- A. Section includes packaged, natatorium environmental control system. Unit shall be specifically designed for natatorium environmental control including dehumidification, pool water heating, and air heating/cooling. The unit shall have fully self-contained microprocessor controller with diagnostics, status reporting and alarm functions.
- B. The dehumidifiers shall be single package units. Each unit shall include compressor(s), evaporator (dehumidifying coil), condenser (air reheat coil), water heater(s), supply air blower(s), blower motor(s), motor starters and controls in one complete enclosure.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of indoor, mechanical dehumidification unit.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each indoor, mechanical dehumidification unit.
  - 1. Include plans, elevations, sections and mounting details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Detail fabrication and assembly of dehumidification units.
  - 4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - 5. Include diagrams for power, signal, and control wiring.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

#### **1.5 COORDINATION**

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

#### **1.6 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace components of indoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than two years from date of Substantial Completion.
  - 2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 INDOOR, MECHANICAL DEHUMIDIFICATION UNIT MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Dectron Internationale.
  - 2. Desert Aire.
  - 3. PoolPak.
  - 4. Innovent
  - 5. Seresco

#### **2.2 UNIT ARRANGEMENT**

- A. The unit shall have a 15' minimum horizontal separation from any exhaust point to any outdoor air intake, including any Purge Mode exhaust points and outdoor air intakes, to inhibit re-entrainment of airborne pool chemicals, moisture removed for dehumidification, and icing of filters and dampers in the outdoor air intake.
- B. Duct connections shall be located as shown on the drawings. Duct connection sizes shall not have a higher face velocity or different aspect ratio than the specified unit.

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- C. Air tunnels shall be arranged as shown on the drawings. Unit height and width shall not be less than the specified unit height and width.
- D. Plenum curbs or raised curbs requiring internal ducting of supply or return air to meet required duct connections are not acceptable in any form.
- E. Filters shall be located within the unit cabinet (not in an external sleeve or in the hood).
- F. All outdoor air intake sections shall be provided with 2" pleated MERV-8 filters at minimum, including normal mode and purge mode intakes.
- G. Maintenance access space and airflow transition space between components shall be provided as shown on the drawings. Unit length shall not be less than the specified unit length.
- H. Fans and/or filters shall not be face mounted on coils or heat transfer components.
- I. The outdoor air intake shall not be located after the unit heating device to prevent risk of condensation and stratification.
- J. If Purge Mode is provided, it shall not require operation of an exhaust fan residing in the corrosive return plenum that is off in normal mode operation.
- K. Recirculation air damper, if required, shall not be located under an air-air heat exchanger due to condensate carryover at the air velocity through the damper.

## **2.3 CONSTRUCTION**

- A. General. Construct unit with materials and features as specified herein. Provide structural base and tube frame to house inset wall, ceiling and floor panels. Unit construction shall meet Cabinet Performance specified in this section. Structural tube frame and panel construction shall be provided with no individual panel exceeding 36" width. All panels on the unit shall be fully removable without the use of cutting tools. All internal components shall be removable without compromising the structural integrity of the unit. Unit shall be suitable for indoor installation as detailed on the plan drawings.
- B. Cabinet Performance. Unit construction shall meet the following minimum performance criteria.
  - 1. Base Deflection. Design structural base to limit deflection to  $\frac{1}{4}$ " in length and width when rigging the unit according to manufacturer recommendations. Provide engineering calculations demonstrating compliance with this requirement.
  - 2. Cabinet Deflection. Construct cabinet to limit deflection of the walls and roof to L/250 at 8" w.c. static pressure, or 1.5 times the maximum static pressure within the unit at design conditions, whichever is lower. Deflection ratings for panels only shall not be accepted.
  - 3. Floor Deflection: Maximum floor deflection shall be L/500 (L=span in inches) when subjected to an 800 lb/sq ft. point load. Provide test data demonstrating compliance with this requirement.
  - 4. Casing Air Leakage. Maximum casing leakage shall meet SMACNA duct leakage class (DLC) rating of 5.0. Provide calculations demonstrating compliance with this requirement.

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5. Casing Insertion Loss (Acoustic rating). The panel insertion loss, per octave band, shall not be less than the following:

<b>Frequency (Hz):</b>	<b><u>100</u></b>	<b><u>125</u></b>	<b><u>250</u></b>	<b><u>500</u></b>	<b><u>1000</u></b>	<b><u>2000</u></b>	<b><u>4000</u></b>	<b><u>8000</u></b>
<b>Insertion Loss (dB):</b>	<b>24</b>	<b>16</b>	<b>30</b>	<b>32</b>	<b>33</b>	<b>34</b>	<b>63</b>	<b>60</b>

6. Thermal Performance. All interior walls, floor, and ceiling shall be double wall and insulated with polyurethane injected foam insulation having a minimum R- value of 6.3 - 7.1/inch. Fiberglass or non-injected foam insulation is not acceptable and will be rejected.
- C. Base. Base shall be constructed of welded 10 ga. structural steel G channel perimeter and C channel cross members with integral lifting lugs. Units without a welded structural steel base that utilize lifting provisions near the top of the cabinet shall be unacceptable. Bolted bases shall not be acceptable. Coat base exterior with 2 part epoxy primer and urethane modified enamel top-coat. Removable lifting lugs shall be provided. Weep holes shall be provided in base channels. Base height shall be a minimum of 8" to facilitate proper trapping of drains.
- D. Frame. Frame shall be constructed of structural tube members designed to support flush-mounted double-wall panels. Vertical frame members shall be easily removable without the use of specialty tools or torches for replacement of large internal components. Welded frame shall not be accepted unless all internal components can be easily removed without cutting any welds. A closed-cell polyvinyl foam gasket with a thickness of 3/16" or greater shall be applied between all frame members and panels, providing a thermal break between the panels and the structural frame. Units without a structural tube frame shall be unacceptable.
1. Frame Material: Extruded 6063 Aluminum Tube
- E. Floor. Floor shall be 2" thick double-wall, foam injected panel construction for optimal support strength. Floor shall be a fastener free design, bonded to the unit base with a structural adhesive. All seams shall be finished with an adhesive sealant providing a watertight floor system. Use of tack welding, caulk or screws penetrating the entire floor panel anywhere in the floor shall not be accepted. The floor shall have a smooth and flat walk-on surface. A minimum 1" lip shall be provided around all floor penetrations. Walk-on grating shall be provided over all accessible floor mounted duct connections. Paneled floor shall be constructed of a minimum of .063" 5052-H32 mill-finished aluminum walk on surface and 22 gauge galvanized steel underside surface.
- F. Wall and Ceiling Panels. Unit shall have non-load bearing, fully removable, heavy gauge 2" double-wall panels which fully encapsulate the injected foam insulation. No individual panel shall exceed 36" width. Panel edges utilizing PVC edge wrappers to cover the insulation shall not be accepted. Panels shall be manufactured with an integral thermal break.
1. Exterior Materials: Exterior skin shall be galvanized G90 steel. Unpainted galvanized exterior shall be unacceptable if unit casing or framework is welded.
2. Interior Materials: Interior skin shall be 5052-H32 mill-finished aluminum.
- G. Thermal Break Construction. The casing (panels and frame) excluding doors, shall meet AHRI 1350 CB-1 requirements.
- H. Insulation. Insulation shall be a product of a manufacturer specializing in insulating materials. All walls, floor, and ceiling shall be double wall and insulated with polyurethane injected foam insulation. Provide a data sheet from the insulation manufacturer confirming an R-value of 6.3 - 7.1 per

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inch. No insulation shall be exposed to the airstream. Non-injected foam board insulation or air handler manufacturer produced insulating material shall not be accepted. Fiberglass, mineral wool, and non-injected foam board insulation shall not be accepted.

- I. Access Doors. Provide double wall doors with the same insulation and inner/outer wall material as the wall panels. Doors shall have an integral aluminum frame and shall be mounted into the structural frame of the unit. Door openings cut into casing panels shall not be accepted. Doors shall be full height (up to 72") with industrial continuous stainless steel hinges. Bi-directional compression latches with integral roller cam and hex-screw locking assembly shall be provided. An EPDM type door gasket shall be provided in accordance with ASTM D 2000. Supply and exhaust airstreams shall not be covered by a single door. Access panels in lieu of access doors shall not be accepted. Rain gutters shall be provided over all access doors that are not the full height of the unit casing. All doors that open with pressure shall be provided with a pressure relief safety latch. Access doors shall be provided for sections requiring routine maintenance.

## **2.4 FLAT PLATE HEAT EXCHANGER**

- A. Provide cross flow air-to-air flat plate heat exchangers with thermal performance, pressure drop, resistance to deformation, material for heat transfer surface, end plates, corners, and frames, method of sealing, leakage rating, pressure differential resistance rating, and warranty as specified herein and scheduled.
- B. Construction. The heat exchanger shall be constructed with the following features:
  1. Heat exchanger plates shall be 8 mil thickness 3003 series aluminum. Plate thickness shall be identified and certified in submittals.
  2. End plates, corners, and frames shall be constructed of aluminum. Full tube frames shall be provided for strength. Formed steel end plates and/or heat exchangers without a full aluminum tube frame shall not be allowed. Formed angle pieces shall not be provided in lieu of the specified aluminum tube frame.
  3. Plate edges shall be both mechanically and with sealant, and the plate corners shall be sealed to the aluminum tube frame to limit cross contamination leakage.
  4. Plates shall be completely smooth, with no dimples or corrugations for contaminants to adhere to. Plate spacing shall be maintained by rigid integral standing ribs spaced every two inches of width. If dimples or corrugations are used for plate separation and/or to create turbulence, a water wash spray manifold with brass nozzles, stainless steel nozzle holders, and a hose bibb connection shall be provided to facilitate cleaning of the heat exchanger.
  5. Airflow path shall be straight through for low pressure drop, ease of surface inspection, washing, and to prevent deposition of contaminants. Counterflow heat exchangers do not meet this requirement and shall not be accepted.
- C. Ratings. The heat exchanger shall have the following ratings:
  1. Maximum operating differential pressure. The heat exchanger shall be capable of operating up to 10" w.c. differential pressure at 70°F.
  2. Air Leakage. Air leakage shall be no more than 0.1% of airflow at 3" w.c. pressure differential

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- D. Performance. The heat exchanger shall meet the following performance criteria:
1. Heat exchanger thermal performance shall be as scheduled.
  2. Pressure drop shall not exceed the scheduled values. Pressure drop shall be corrected due to plate deflection resulting from operating pressure differential if required by the heat exchanger manufacturer. The corrected value shall not exceed the scheduled value.
- E. Mounting in the Air Handler. The heat exchanger shall be applied in the air handler in the following manner:
1. Heat exchanger shall be mounted in the diagonal orientation with side-by-side air-streams.
  2. Clean-in-place design. Provide exhaust air drain pan to collect condensate during cold weather operation and wash water when maintenance is required. Provide outside air drain pan to collect wash water when maintenance is required. Drain pans shall be double-sloped per IAQ requirements and shall be constructed of aluminum. Drain pan coverage shall extend below the entire heat exchanger. Drain connections shall be through the side of the unit.
  3. If the heat exchanger is not manufactured by the unit manufacturer, provide written certification that all heat exchanger manufacturer recommendations affecting airflow and performance have been incorporated into the air handler design, including recommended transition space to fans and clearances from the top and bottom of the plenum. Include a list of the recommendations and demonstrate that the air handler is in compliance.
- F. Drain lines shall be properly trapped and freeze protected by the installing contractor.
- G. Provide Magnehelic differential pressure gages across the outside air and exhaust air sides of the air-to-air heat exchanger.
- H. Acceptable Manufacturers. Innovent (basis of design), or approved equal by Heatex AB, model P only, pressure resistant crossflow heat exchanger.
- I. A ten (10) year non-prorated parts warranty shall be provided for all flat plate air-to-air heat exchangers. The warranty period shall begin at start up or six (6) months after shipment, whichever occurs first.

## **2.5 BLOWER/MOTOR**

- A. Supply Blower; Exhaust Blower;
1. Standard of Quality. Fans shall be Greenheck APD, Twin City EPQN, or Cook model PLC with construction details as specified below.
  2. Wheel. The fan wheel shall be non-overloading centrifugal type. Wheel shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
    - a. The supply fan wheel shall be manufactured with a minimum of seven, stitch welded aluminum backward curved blades.



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- b. The exhaust fan wheel shall be manufactured with a minimum of seven, stitch welded aluminum backward curved blades.
  - c. Fan wheel shall be finished with a protective coating to inhibit corrosion.
  - d. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
- 3. Construction. Plenum fans shall be of the unhooded direct drive centrifugal type.
  - a. Fan plate shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
  - b. Panels and framework shall be constructed of precision laser cut and die formed galvanized steel to provide a rigid structure to support the drive motor, shaft, bearings and wheel and reduce low frequency vibration.
  - c. Each fan shall be given an electronic vibration analysis in accordance with ANSI/AMCA Standard 204, while operating at the specified fan RPM. The vibration signatures shall be taken at motor mounting pedestal in the horizontal, vertical and axial direction. The maximum allowable fan vibration shall be 0.10 in./sec peak velocity, filter-in as measured at the fan RPM.
  - d. Steel parts shall be coated with Hi-Pro Polyester urethane powder coating or 2 part epoxy primer and urethane modified enamel topcoat.
- 4. Motor. Motors shall meet or exceed EISA (Energy Independence and Security Act) efficiencies. Motors shall be 3-phase NEMA T-frame, 60 Hz, with RPM as scheduled.
  - a. Enclosure shall be Totally Enclosed Fan Cooled (TEFC).
  - b. Motor housing shall be cast iron.
  - c. Service factor shall be 1.15.
  - d. Insulation shall be Class F.
  - e. Motors shall be variable frequency drive (VFD) compatible.
  - f. Motors 10 HP and larger shall be provided with shaft grounding rings.
- 5. Performance. Conform to ANSI/AMCA Standards 210 and 300. Fans shall be tested in accordance with AMCA Publications 211 and 311 in an AMCA accredited laboratory and certified for air and sound performance. Fans shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210) and sound performance (AMCA 300).
  - a. Fan brake horsepower shall not exceed the scheduled brake horsepower at the total static pressure and airflow scheduled.
  - b. Provide the number of fans scheduled, no exceptions.
  - c. Fan motors shall be selected to run at no more than 90 Hz at design conditions.

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6. Mounting. Blower and motor shall be mounted on a unitary isolation base.
  - a. Structural steel fan/motor base shall be designed by the manufacturer to properly support the fan/motor assembly to mitigate vibration.
  - b. 1" deflection housed seismic rated spring isolators shall be provided.
  - c. Fan inlets shall be connected to a double wall foam injected plenum wall.
  - d. Fans shall be connected to the plenum wall with canvas flex connectors with aluminum edge caps.
- B. Variable Frequency Drives: Provide variable speed drive for all plenum fans. VFDs shall be factory provided and factory installed. See Electrical section of this unit specification for more VFD requirements.

## 2.6 DAMPERS

- A. Standard of Quality. Dampers shall be manufactured by Greenheck, Ruskin, or T. A. Morrison, with specific models called out below.
- B. Dampers shall meet or exceed the following construction and ratings.
  1. Outside Air Damper; HX Face Damper; HX Bypass Damper;
    - a. Steel Frame and Blade Dampers, Formed Blade
      - i. Construction
        - Frame Material: 16 ga. galvanized steel, 5" x 1" hat channel
        - Blade Material: Galvanized steel
        - Blade Type: Formed 3V
        - Linkage: Plated steel concealed in the jamb (out of airstream). Plastic and/or gear driven linkages shall not be allowed
        - Axle Material: Plated steel
        - Axle Bearings: Acetal (synthetic) sleeve
        - Blade Seals: TPE
        - Jamb seals: Stainless steel
      - ii. Ratings. AMCA Class 1A rated at 1" w.c. and Class 1 up to 5" w.c. with AMCA certified performance for pressure drop and leakage per AMCA 500-1D, Test Figures 5.2, 5.3, and 5.5.
        - Velocity Limit: Suitable for use to 3000 feet per minute
        - Leakage: 3 cfm/sq. ft (AMCA Class 1A)

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- Temperature Range: -40 deg F to 250 deg F
  - Pressure Limit: Suitable for use to 5" w.c.
  - iii. Manufacturer and Model Provide Greenheck model VCD-23, Ruskin CD-36, or T. A. Morrison model 1000
2. Recirculation Damper; Exhaust Air Damper;
- a. Aluminum Frame and Blade Dampers, Airfoil Blade.
    - i. Construction
      - Frame Material: 0.125" thick aluminum, 5" x 1" hat channel
      - Blade Material: 0.063" thick extruded aluminum
      - Blade Type: Airfoil
      - Linkage: Plated steel concealed in the jamb (out of airstream). Plastic and/or gear driven linkages shall not be allowed
      - Axle Material: Minimum 1/2" plated steel
      - Axle Bearings: Acetal (synthetic) sleeve
      - Blade Seals: TPE
      - Jamb seals: Stainless steel
    - ii. Ratings. AMCA Class 1A rated at 1" w.c. and Class 1 up to 4-10" w.c. with AMCA certified performance for pressure drop and leakage per AMCA 500-1D, Test Figures 5.2, 5.3, and 5.5. Dampers shall be IECC compliant.
      - Velocity Limit: Suitable for use to 6000 feet per minute
      - Leakage: 3 cfm/sq. ft (AMCA Class 1A)
      - Temperature Range: -40 deg F to 250 deg F
      - Pressure Limit: Suitable for use to 10" w.c.
    - iii. Manufacturer and Model Provide Greenheck model VCD-43, Ruskin CD-50, or T. A. Morrison model 1500
- C. The following dampers shall be provided at a minimum (additional dampers may be required, please consult the sequence of operation to determine what is needed):
- 1. Outside Air Control Damper, modulating actuator
  - 2. Heat Exchanger Face Damper, modulating actuator

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3. Heat Exchanger Bypass Damper, modulating actuator
4. Recirculation Air Control Damper, modulating actuator
5. Exhaust Air Shut-off Damper, 2-position actuator

## **2.7 FILTERS**

- A. General Requirements. Provide filters as specified in this section. Filter racks shall be blanked off to the unit casing to inhibit air bypass. Filters shall be located within the air handling unit cabinet and shall not be in a hood or duct sleeve outside of the air handler cabinet.
- B. Outside Air Pleated Filter: Provide a flat bank or V-bank filter section as shown on the unit drawing and as follows:
  1. Depth and Rating: 2" MERV-8
  2. Location: Mount filters immediately downstream of the outside air inlet.
  3. Rack: Provide an aluminum side access slide rack. Rack shall include vertical formed U-channels attached to the frame at intervals across the rack to protect against filter media getting pulled through the rack.
  4. Face Velocity: Provide filters sized for 500 fpm maximum face velocity, but no higher than the scheduled value.
  5. Filters shall be rated per U.L. standard 900.
- C. Aluminum filter (washable): Provide a flat bank or V-bank filter section as shown on the unit drawing and as follows:
  1. Depth: 2"
  2. Location: Mount filters immediately after the return air inlet or as shown on the unit drawing.
  3. Rack: Provide an aluminum side access slide rack. Rack shall include vertical formed U-channels attached to the frame at intervals across the rack to protect against filter media getting pulled through the rack.
  4. Face Velocity: Provide filters sized for maximum 650 fpm face velocity, but no higher than the scheduled value.

## **2.8 HOT WATER COIL**

- A. Standard of Quality. Provide coils as manufactured by Precision Coils, Modine, or Aerofin meeting all construction features and performance parameters as specified in this section and the project schedule.
- B. Provide reheat coils as scheduled.
- C. Construction. Provide coils with the following material types and thicknesses:

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1. Fins: 0.006" thick aluminum
  2. Tubes: 0.02" thick seamless copper
  3. Tube Diameter: 5/8"
  4. Casing: galvanized steel
- D. Performance. Provide coils meeting the following performance parameters:
1. System parameters (provide as scheduled):
    - a. Fluid: water, or glycol type and percentage if scheduled
    - b. Entering fluid temperature
    - c. Water temperature drop
  2. Face Velocity: Not to exceed the scheduled value
  3. Air Pressure Drop: Not to exceed the scheduled value
  4. Water Pressure Drop: Maximum 10' w.c., but not to exceed the scheduled value
  5. GPM: Not to exceed the scheduled value
  6. Heat Transfer Surface:
    - a. Rows: Provide the number of rows scheduled
    - b. Fin Density: Maximum 14 fins/inch, but not to exceed the number of fins/inch scheduled
- E. Piping Connections. Coil connections shall be stubbed through unit casing. Supply and return connections up to 2" diameter shall be copper sweat type. Connections larger than 2" shall be steel grooved connections.
- F. Coil Coating(s).
1. Reheat: Electrofin E-Coat

**2.11 CHILLED WATER COIL**

- A. Standard of Quality. Provide ARI rated coils as manufactured by Precision Coils, Modine, or Aerofin meeting all construction features and performance parameters as specified in this section and the project schedule.
- B. Construction. Provide coils with the following material types and thicknesses.
1. Fins: 0.006" thick aluminum
  2. Tubes: 0.02" thick seamless copper
  3. Tube Diameter: 5/8"

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4. Casing: galvanized steel
- C. Performance. Provide coils meeting the following performance parameters:
1. System parameters:
    - a. Fluid: Water, or glycol type and percentage as scheduled
    - b. Entering fluid temperature
    - c. Water temperature rise
  2. Face Velocity: Minimum 250 fpm, maximum 500 fpm, but not to exceed the scheduled value
  3. Air Pressure Drop: Not to exceed the scheduled value
  4. Water Pressure Drop: Maximum 20' w.c., but not to exceed the scheduled value
  5. GPM: Not to exceed the scheduled value
  6. Heat Transfer Surface:
    - a. Rows: Provide the number of rows scheduled
    - b. Fin Density: Maximum 12 fins/inch, but not to exceed the number of fins/inch scheduled
    - c. Turbulators: Provide turbulators only if scheduled
- D. Cooling Coil Drain Pan. All cooling coils shall be provided with aluminum IAQ drain pans that begin at the entering air side of the coil face and extend a minimum of 12" past the leaving air side of the coil face. Entire underside of the drain pan, including the piping run to the casing exterior, shall be coated with no less than 2" of spray foam insulation to ensure no sweating occurs below. Coil shall be installed on "walk-on" supports spaced a maximum of 6" apart to allow full access to the coil face without damage to the drain pan. Pans without the feature shall not be accepted. The drain pan shall be sloped in a minimum of 2 directions to ensure proper drainage. The drain shall be located on the bottom of the drain pan and the connection countersunk below the surface of the drain pan to eliminate the potential for standing water at the connection. No side connections in the pan shall be allowed. An integral intermediate drain pan shall be provided for tall coils in applications where condensate is expected. The intermediate pan shall be factory piped with PVC piping to the main drain pan.
- E. Piping Connections. Coil connections shall be stubbed through unit casing. Supply and return connections up to 2" diameter shall be copper sweat type. Connections larger than 2" shall be steel grooved connections.

## **2.12 ELECTRICAL**

- A. General Requirements.
1. Units shall be provided fully factory wired per the requirements of this section.

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2. Units shall be ETL listed to the Standard for Safety for Heating and Cooling Equipment, ANSI/UL Standard 1995 and CAN/CSA C22.2 No. 236-05. Factory wiring practices, safety provisions, components, and labeling shall be per the requirements of the ETL listing.
3. All major electrical components shall be UL listed.

B. Wiring Requirements.

1. Power wiring shall be enclosed in conduit.
2. Ladder wiring diagrams shall be provided. Lines on the diagram shall be numbered, and the associated wires shall be numbered at both terminations for help in troubleshooting.
3. Wires shall be color coded per voltage (line voltage/120V/24V) in the Electrical Panel, and per function from the terminal blocks in the Electrical/Control panel to end devices. Color coding shall be called out on the ladder diagram.
4. Provide units with an SCCR rating of 5kA.
5. Provide dedicated wires to end devices (transducers, analog sensors, etc.) to limit potential electrical interference.
6. Wiring and conduit penetrations through panels or block-offs shall be provided with a grommet per metal surface to protect against electrical short circuiting and abrasion, and sealed with sealant to prevent leakage.

C. Major Components.

1. Non-Fused disconnect shall be provided by the unit manufacturer and mounted by the unit manufacturer.
2. Electrical/Control Panels(s). Provide NEMA 3R panel or panels as required
  - a. Provide exterior panels or flush mounted enclosures as shown on the unit drawings.
  - b. Provide a backplate within the panel for mounting of electrical components, DDC controllers and expansion boards, control transformers, required fusing, service switch, VFDs (where applicable) and terminal blocks.
  - c. For rooftops units, exterior panels housing VFDs shall be mechanically ventilated and provided with electric strip heaters. Flush mounted panels shall be ventilated by the unit airstream.
3. Variable Frequency Drives shall be factory provided, wired and programmed.
  - a. VFDs for supply fan shall be ABB Model ACS320
  - b. VFDs for exhaust fan shall be ABB Model ACS320
  - c. Individual branch fusing per VFD shall be provided by the unit manufacturer.

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- d. VFD Mounting. For indoor units, mount VFDs on the unit exterior. For outdoor units provide exterior NEMA 3R enclosure or flush mounted enclosure as shown on the unit drawings. Provide a backplate within the enclosure for mounting of VFDs.
  - e. Mounting Location:
    - i. Blower VFDs shall be located on the exterior of the unit.
4. Motor protection. Motors (including compressors) not controlled using VFDs shall have motor starter protectors and contactors rated for the duty.

## 2.13 DDC SYSTEM

- A. Manufacturer shall provide a programmable digital control system for each custom unit. A user terminal with LCD display shall provide capability of monitoring operation and changing setpoints through an integral keypad. The user terminal shall be capable of being either unit mounted (UUT) or remote mounted (RUT) using straight through six wire flat cable. The manufacturer shall program the sequence of operation as specified in this section. The program shall include the following:
- 1. Unit start-up and shut-down requirements including fan/airflow proving indication and damper actuator end switch indication.
  - 2. Temperature control for all heating and cooling devices.
  - 3. Humidity control for all dehumidification devices and processes.
  - 4. Economizers (dry-bulb, enthalpy, dewpoint, energy recovery) where applicable.
  - 5. Fan controls for each mode of operation.
  - 6. Requirements for modes of operation other than Normal Occupied mode.
  - 7. Integration of all optional devices (firestats, smoke detectors, pressure transducers, air-flow stations, etc) specified in this section.
  - 8. Alarms:
    - a. Informational auto-reset alarms shall be provided and stored for all sensors, end devices, and components, and shall be accessible through the controller user interface.
    - b. Manual reset alarms shall be provided as specified for some optional devices (e.g. firestats, freezestats, smoke detectors, fan duct static pressure limits) and where required to protect the space served or the equipment.
    - c. A list of standard alarms available to the BAS shall be included in the points list as specified in this section.
- B. The controller shall communicate with the Building Automation System (BAS) through a factory provided BACnet MS/TP interface card. A points list necessary to control the equipment, perform



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the sequence of operation, and informational points required by the BAS shall be provided as specified in this section.

- C. The controller shall have the capability through a web-based User Interface to remotely monitor all inputs/outputs, control the user terminal, view status of all alarms including both alarm and cleared time stamps, remotely upload a new program, and view historical and live log data for the past 24 hours. The controller shall save the log data for a rolling 7 days in a csv file that can be downloaded, with the additional capability of storing 31 days of logged data to an external thumb drive.
- D. Alarm Indication. DDC controller shall have one digital output for remote indication of an alarm condition. (i.e. Blower current switch, differential pressure switch, damper end switch, supply discharge low limit, freeze stat, fire stat, smoke, dirty filters...). Alarm Indication shall be configurable to indicate only shut down alarms if desired. The type of alarm shall be distinguishable through the BMS.
- E. Sequence of Operation. Manufacturer shall provide the sensors required for the Sequence of Operation, including additional points listed in the BMS Points listed when included in this section. The sequence of operation shall incorporate devices such as smoke detectors, filter switches or transducers, and kill switches specified in the Electrical section of this equipment specification.
- F. BMS Points List. [Insert Standard BMS Points List from Sequence of Operation generated by the Sequence Generator].

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hot-water and refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Equipment Mounting:
  - 1. Install dehumidification units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

### **3.3 PIPING CONNECTIONS**

- A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
- B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
- C. Connect condensate drain pans using minimum NPS 1-1/4 copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
- D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping." Connect to supply and return coil tapings with shutoff valve and union or flange at each connection.
- E. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect to supply coil tapings with shutoff valve, return coil tapings with balancing valve, and union or flange at each connection.
- F. Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
  - 1. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure, and insulate the space between roof and bottom of dehumidification unit.

### **3.4 ELECTRICAL CONNECTIONS**

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
  - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
  - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.
  - 3. Locate nameplate where easily visible.

### **3.5 CONTROL CONNECTIONS**

- A. Install control and electrical power wiring to field-mounted control devices.

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- B. Connect control wiring between control devices.
- C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
- D. Connect smoke detector to fire alarm system.

### **3.6 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
  - 2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Dehumidification unit will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.7 CLEANING**

- A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
- B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

### **3.8 ADJUSTING**

- A. Adjust damper linkages for proper damper operation.
- B. Adjust initial temperature and humidity set points.

### **3.9 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.

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B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

### **3.10 DEMONSTRATION**

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

### **END OF SECTION 23 8416.16**

**SECTION 26 0500**

**COMMON WORK RESULTS FOR ELECTRICAL**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specified Elsewhere:
  - 1. Divisions 03-11 – Architectural Specifications and Drawings
  - 2. Division 21 – Fire Suppression Specifications and Drawings
  - 3. Division 22 – Plumbing Specifications and Drawings
  - 4. Division 23 – HVAC Specifications and Drawings
  - 5. Division 26 – Other Electrical Specifications and Drawings
  - 6. Division 27 – Electrical Communication Specifications and Drawings
  - 7. Division 28 – Electronic Safety and Security Specifications and Drawings
  - 8. Divisions 31-33 – Site Work Specifications and Drawings

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Labor and materials for complete electrical systems. These materials include, but are not limited to; circuit breakers, devices, boxes, conduit, conductors, connectors, fittings, and anchors, as required and/or indicated in these specifications and/or shown on the Electrical drawings.
  - 2. Power connections and control equipment and wiring, as required for equipment furnished and installed under other sections or by Owner.
  - 3. All minor system components reasonably required for the proper functioning and/or safe operation of the electrical systems, and to meet all related codes and ordinances.
  - 4. Required system and component testing, as required in associated specification sections and/or related codes and ordinances.
  - 5. Coordination with other trades, Owner(s), suppliers, utilities, and Authorities Having Jurisdiction.
  - 6. General requirements included in this section apply to all other Division 26, 27, and 28 specifications and drawings.

### **1.3 DEFINITIONS**

- A. ADA: Americans with Disabilities Act
- B. AHJ: Authority Having Jurisdiction
- C. FBO: Furnished by Others
- D. IAC: Illinois Accessibility Code
- E. IBC: International Building Code
- F. IECC: International/Illinois Energy Conservation Code
- G. IFC: International Fire Code
- H. NEC: National Electrical Code (NFPA 72)
- I. NFPA: National Fire Protection Association
- J. Provide: Furnish and install.

### **1.4 VERIFICATION OF CONNECTION POINTS**

- A. Before submitting his proposal, Contractor shall visit the site to carefully verify all exposed points of existing utilities and new connections. Contractor shall verify concealed or buried points for connection, as near as possible. Verify these points as to locations, size, type, depth, operating characteristics, and complications; including, but not limited to:
  - 1. Present site conditions.
  - 2. Present and new electrical utility distribution system and requirements.
  - 3. Present and new communication utilities' distribution system and requirements.
  - 4. Work associated with equipment provided under other sections, or by Owner.

### **1.5 COORDINATION**

- A. Coordinate all work per requirements of Division 1.
- B. See mechanical, plumbing, and architectural specifications, drawings, and submittals for work concerning the connection of electrical systems and any required controls.
- C. Contractor shall verify electrical characteristics and requirements (name plate data) of equipment furnished by others for proper coordination and equipment operation. Contractor shall confirm requirements of final equipment furnished by others and shall select associated electrical devices and materials accordingly. Before any work is installed, and before any equipment is purchased, the Contractor shall carefully inspect specifications and plans for every trade and job condition, and any lack of coordination between his work, the plans, specifications, or job conditions, shall be immediately reported to the Architect/Engineer in writing.

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- D. Contractor shall coordinate equipment connection requirements with approved equipment submittals, prior to rough-in.
- E. Coordinate arrangement, mounting, and support of electrical equipment;
  - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
  - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
  - 3. To allow right of way for piping and conduit installed at required slope.
  - 4. So connecting raceways, cables and wireways will be clear of obstructions and of the working and access space of other equipment.
- F. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- G. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.
- H. Coordinate sleeve selection and application with selection and application of firestopping.

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS**

- A. When two or more items of the 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, motors for dissimilar equipment units, and similar items in Work, except as otherwise indicated.
- B. Provide products compatible within systems, with interconnected systems, and with other connected items.
- C. Products shall be provided with permanent operational data nameplate for 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. Locate nameplate in an accessible location.

### **2.2 PRODUCT OPTIONS AND SUBSTITUTIONS**

- A. Options and Substitutions shall be done per Division 1 instructions.
- B. All product substitutions shall include any incurred costs by the Contractor, any sub-contractor, other trades, Owner, or Owner's consultants. No increase in cost or contract shall be allowed for modifications or corrections, due to approval of Contractor requested changes or substitutions.

## **2.3 SUBMITTALS FOR ELECTRICAL ITEMS**

- A. Submit per Division 1 specification requirements.
- B. Electrical equipment and material submittals shall include a clear item description. Catalog numbers only, are not acceptable.
- C. Catalog pages must be clearly marked to indicate the exact product being proposed, with all necessary accessories and options identified and selected. Pages including multiple products or options, where selections are not clearly indicated, may be rejected for re-submittal.

## **2.4 DELIVERY, STORAGE AND HANDLING**

- A. Deliver products and materials to project site with proper identification, including; names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
- B. Store equipment and materials at the site unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. 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 smooth and efficient flow of installations.

# **PART 3 - EXECUTION**

## **3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION**

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Coordinate electrical equipment and materials installation with other building components.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- F. Right of Way: Give to piping systems installed at a required slope.
- G. Verify all dimensions with field measurements.



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- H. Arrange for chases, slots, and openings in other building components to all for electrical installations.
- I. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of work.
- J. Coordinate the cutting and patching of building components to accommodate the installation of electrical equipment and materials.
- K. Install electrical equipment for compliance with code-required clearances. Contractor shall be responsible for identification of necessary clearance issues at the time products are submitted for approval.
- L. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment, piping, ductwork, and other systems and structural components.
- M. Drawings for work under Divisions 26, 27, and 28 are diagrammatic and are intended to convey the scope of work and indicate the general arrangement of conduit, boxes, equipment, lighting fixtures, and other work included in the contract.
  - 1. See details and schedules on drawings and specifications for meanings of abbreviations, additional requirements and information. Check civil, structural, mechanical, plumbing, and other electrical drawings for scale, space limitations, beams, door swings, windows, ductwork, coordination, and additional information, and report any discrepancies or conflicts to Architect/Engineer prior to submitting bid.
  - 2. The Contractor shall install and completely wire all equipment furnished by others (FBO) in accordance with the manufacturer's wiring diagrams and recommendations, necessary for a complete and operational installation. Contractor shall verify and coordinate electrical characteristics and requirements of FBO equipment prior to ordering associated equipment and materials, or rough-in of boxes, conduit, and wiring, to avoid conflicts.

### **3.2 RECORD DOCUMENTS**

- A. Provide Record Documents as required by the Section and Division 1 specifications.
- B. Mark drawings to indicate revisions to conduit size and location, both exterior and interior, actual equipment locations, and concealed equipment dimensioned to column lines or wall face. Record distribution and branch electrical circuitry, fuse and circuit breaker size and arrangements, and support and hanger details.
- C. Accurately mark locations of underground and under floor electrical conduits and conductors. Provide dimensions from fixed points of reference.
- D. Record Change Orders, Supplemental Instructions, or Field Directives, that modify work shown in contract documents, on drawings and in specifications.

### **3.3 OPERATION AND MAINTENANCE DATA**

- A. Procedures and requirements for preparation and submittal of maintenance manuals shall be done as required by Division 1.
- B. In addition to the information required by Division 1 specifications, include the following information when requested:
  - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
  - 2. Manufacturers' printed operating procedures to include start-up, break-in, and routine and normal operating instructions.
  - 3. Maintenance procedures for routine preventative maintenance and trouble-shooting, disassembly, repair, and reassembly, aligning and adjusting instructions.

### **3.4 WARRANTIES**

- A. Procedures and submittal requirements for warranties shall be done as directed by the Division 1 specifications, and as pertains to specific warranties. See individual specification sections for warranty requirements that exceed 1 year or are otherwise distinct.
- B. Compile and assemble warranties specified for Divisions 26, 27, and 28 into a file folder labeled for this project.
- C. Provide complete warranty information for each product or equipment item, to include date of beginning of warranty or bond, duration of warranty or bond, and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- D. Except as modified in individual specification sections:
  - 1. All materials and workmanship shall be warranted for 1 year.
  - 2. All warranties begin upon official date of substantial completion, allowing Owner's beneficial use of the work.
  - 3. Warranted materials shall be provided for replacement within 30 days of notice of failure to Contractor (or as specifically allowed by Owner's Representative).
  - 4. The first year of warranted items shall include materials and labor for replacement/repair and shall be responded to within 10 working days of notice of problem to Contractor. If the issue is of a severe nature, with the use of the facility at risk, response shall be within 2 calendar days.
  - 5. Warranty material replacements shall not diminish the Owner's stock of extra items.

### **3.5 CLEANING**

- A. General requirements for final cleaning shall be done as required by Division 1.
- B. Maintain clean work spaces with daily cleanup of all occupied areas.

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**3.6 TESTING**

- A. Provide testing and documented results as required by each specification section or applicable codes, laws, and ordinances.
- B. Provide testing and documented results as required by manufacturer(s) for certification or warranty.

**END OF SECTION 26 0500**



**SECTION 26 0519**

**LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Building wires and cables rated 600 V and less.
  - 2. Connectors, splices, and terminations rated 600 V and less.

**1.3 DEFINITIONS**

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

**1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

**1.5 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

**PART 2 - PRODUCTS**

**2.1 CONDUCTORS AND CABLES**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Alcan Products Corporation; Alcan Cable Division.
  - 2. American Insulated Wire Corp.; a Leviton Company.

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3. General Cable Corporation.
  4. Senator Wire & Cable Company.
  5. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.
- D. Multiconductor Cable: Not permitted.

## **2.2 CONNECTORS AND SPLICES**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AFC Cable Systems, Inc.
  2. Hubbell Power Systems, Inc.
  3. O-Z/Gedney; EGS Electrical Group LLC.
  4. 3M; Electrical Products Division.
  5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

## **PART 3 - EXECUTION**

### **3.1 CONDUCTOR MATERIAL APPLICATIONS**

- A. Feeders: Copper. Stranded for all conductors.
- B. Branch Circuits: Copper. Stranded for all conductors.

### **3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway. Homerun conductors shall be minimum #10 AWG.
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway. Metal-clad multi-conductor cable is not permitted. Homerun conductors

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shall be minimum #10 AWG. Metal-clad, multi-conductor cable (MC) is not permitted without specific documented allowance.

- F. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- G. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- H. Class 2 Control Circuits: Type THHN-THWN, in raceway.

### **3.3 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

### **3.4 CONNECTIONS**

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
  - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

### **3.5 FIELD QUALITY CONTROL**

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Test Reports: Prepare a written report to record the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

**END OF SECTION 26 0519**





**SECTION 26 0523**

**CONTROL-VOLTAGE ELECTRICAL POWER CABLES**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Low-voltage control cabling.
  - 2. Control-circuit conductors.
  - 3. Identification products.

**1.3 DEFINITIONS**

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

**1.4 QUALITY ASSURANCE**

- A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - 1. Flame-Spread Index: 25 or less.
  - 2. Smoke-Developed Index: 50 or less.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

**1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Test cables upon receipt at Project site.
  - 1. Test each low voltage cable for open and short circuits.

## **1.6 PROJECT CONDITIONS**

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

## **PART 2 - PRODUCTS**

### **2.1 PATHWAYS**

- A. Support of Open Cabling: NRTL labeled for support of cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
- B. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
  - 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

### **2.2 LOW-VOLTAGE CONTROL CABLE**

- A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
  - 1. Size and configuration as recommended by the manufacturer.
  - 2. PVC insulation.
  - 3. PVC jacket.
  - 4. Flame Resistance: Comply with NFPA 262.
  - 5. All cabling shall be furnished and installed per equipment manufacturer's recommendations.

### **2.3 CONTROL-CIRCUIT CONDUCTORS**

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway, complying with UL 83.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway or power-limited cable, concealed in building finishes, complying with UL 83.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

### **2.4 IDENTIFICATION PRODUCTS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Brady Corporation.
  - 2. HellermannTyton.

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3. Kroy LLC.
4. Panduit Corp.
- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF PATHWAYS**

- A. Install manufactured conduit sweeps and long-radius elbows if possible.
- B. Pathway Installation in Equipment Rooms:
  1. Secure conduits to backboard if entering room from overhead.
  2. Extend conduits 3 inches above finished floor.
  3. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

#### **3.2 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
  1. Terminate all conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets and terminals.
  2. Cables may not be spliced. Secure and support cables at intervals not exceeding 60 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  3. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii.
  4. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
  5. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. Installation of Control-Circuit Conductors:
  1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- D. Open-Cable Installation:
  1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

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2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
4. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
5. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

### **3.3 CONTROL-CIRCUIT CONDUCTORS**

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.
4. Minimum sizes may be modified if manufacturer's recommendations are different.

### **3.4 FIELD QUALITY CONTROL**

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and labeling of all components.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

**END OF SECTION 26 0523**

**SECTION 26 0526**

**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section includes grounding and bonding systems and equipment.

**1.3 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
  - 1. Ground rods.
  - 2. Ground rings.
  - 3. Grounding arrangements and connections for separately derived systems.

**1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
      - 1) Ground rods.
      - 2) Ground rings.
      - 3) Grounding arrangements and connections for separately derived systems.

**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.

## **2.2 MANUFACTURERS**

- A. Provide products that meet project requirements from the following, or other approved manufacturers:
  - 1. Appleton
  - 2. Arlington
  - 3. Bridgeport
  - 4. Burndy
  - 5. Erico
  - 6. Greaves
  - 7. Harger
  - 8. ILSCO
  - 9. Panduit
  - 10. RACO
  - 11. Thomas & Betts

## **2.3 CONDUCTORS**

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Stranded Conductors: ASTM B 8.
  - 2. Sizes and types of conductors in four subparagraphs below are typical examples. 28-kcmil bonding cable in "Bonding Cable" Subparagraph below is slightly larger than No. 6 AWG.
  - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
  - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - 5. 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- D. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- E. Conduit Hubs: Mechanical type, terminal with threaded hub.

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- F. Ground Rod Clamps: Exothermic or one-shot compression type, copper or copper alloy, terminal with hex head bolt.
- G. Straps: Solid copper, copper lugs. Rated for 600 A.
- H. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- I. Water Pipe Clamps:
  - 1. Mechanical type, two pieces with zinc-plated bolts.
    - a. Material: Tin-plated aluminum.
    - b. Listed for direct burial.
  - 2. U-bolt type with malleable-iron clamp and copper ground connector.

## **2.5 GROUNDING ELECTRODES**

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

## **PART 3 - EXECUTION**

### **3.1 APPLICATIONS**

- A. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.
  - 1. Bury at least 24 inches below grade.
  - 2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
- B. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors.
  - 3. Connections to Structural Steel: Welded connectors.

### **3.2 GROUNDING AT THE SERVICE**

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

### **3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS**

- A. Comply with IEEE C2 grounding requirements.

- B. Grounding Handholes: Install a driven ground rod through handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.
- C. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

### **3.4 EQUIPMENT GROUNDING**

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
  - 1. Retain applicable subparagraphs below.
    - 2. Feeders and branch circuits.
    - 3. Lighting circuits.
    - 4. Receptacle circuits.
    - 5. Single-phase motor and appliance branch circuits.
    - 6. Three-phase motor and appliance branch circuits.
    - 7. Flexible raceway runs.
- C. Water Heater and Heat-Tracing Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

### **3.5 FENCE GROUNDING**

- A. Fence Grounding: Install at maximum intervals of 40 feet except as follows:
  - 1. Gates and Other Fence Openings: Ground fence on each side of opening.
    - a. Bond metal gates to gate posts.
    - b. Coordinate subparagraph below with Drawings for projects where intentional discontinuities are provided in metal-fencing conductivity to localize lightning effects to the vicinity of strokes.



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- c. Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
- B. Fences Enclosing Electrical Power Distribution Equipment or Mechanical Equipment: Ground as required by IEEE C2 unless otherwise indicated.
- C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

### 3.6 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.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
  - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  - 2. Use exothermic welds for all below-grade connections.
  - 3. Retain subparagraph below if grounding installation requirements are not indicated on Drawings. Subparagraph exceeds NFPA 70 requirements.
  - 4. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

G. 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.

### 3.7 FIELD QUALITY CONTROL

A. 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.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
  - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage

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- and without chemical treatment or other artificial means of reducing natural ground resistance.
  - b. Perform tests by fall-of-potential method or the attached rod technique according to IEEE 81.
  - c. Coordinate subparagraph below with "Informational Submittals" Article; revise to suit Project.
4. Prepare dimensioned Drawings locating each ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- B. Grounding system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Report measured ground resistances that exceed the following values:
- 1. See the Evaluations for discussion on appropriate ground-resistance values. Typical maximum permitted values are listed below for different grounding applications; retain applicable subparagraphs and revise to suit Project. Coordinate with requirements in Sections specifying equipment to be grounded.
  - 2. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 3 ohms.
  - 3. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 3 ohms.
  - 4. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  - 5. Substations and Pad-Mounted Equipment: 3 ohms.
- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect/Engineer promptly and include recommendations to reduce ground resistance.

**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 the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Hangers and supports for electrical equipment and systems.
  - 2. Construction requirements for concrete bases.

**1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

**1.4 PERFORMANCE REQUIREMENTS**

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

**1.5 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Steel slotted support systems.

**1.6 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

## **1.7 COORDINATION**

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## **PART 2 - PRODUCTS**

### **2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS**

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
  - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Allied Tube & Conduit.
    - b. Cooper B-Line, Inc.; a division of Cooper Industries.
    - c. ERICO International Corporation.
    - d. GS Metals Corp.
    - e. Thomas & Betts Corporation.
    - f. Unistrut; Tyco International, Ltd.
    - g. Wesanco, Inc.
  - 2. Retain one or more coating systems in first three subparagraphs below. If retaining more than one, specify in Part 3 where each coating system is required.
  - 3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
  - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-5.
  - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
  - 1. Verify suitability of fasteners in subparagraph below for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

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- a. See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers and products. Retain one of first two subparagraphs and list of manufacturers below. See Division 01 Section "Product Requirements."
- b. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
  - 2) Empire Tool and Manufacturing Co., Inc.
  - 3) Hilti Inc.
  - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
  - 5) MKT Fastening, LLC.
- 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
- 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
- 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
- 6. Toggle Bolts: All-steel springhead type.
- 7. Hanger Rods: Threaded steel.

## **2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES**

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

## **PART 3 - EXECUTION**

### **3.1 APPLICATION**

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
  - 1. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps, or single-bolt conduit clamps using spring friction action for retention in support channel.

- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

### **3.2 SUPPORT INSTALLATION**

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  - 1. To Wood: Fasten with lag screws or through bolts.
  - 2. To New Concrete: Bolt to concrete inserts.
  - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  - 4. To Existing Concrete: Expansion anchor fasteners.
  - 5. Retain first subparagraph below if powder-actuated devices are allowed. Consider deleting if Project contains both lightweight and standard-weight concrete or more than one thickness of concrete slab.
  - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69, or Spring-tension clamps.
  - 7. To Light Steel: Sheet metal screws.
  - 8. 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.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

### **3.3 INSTALLATION OF FABRICATED METAL SUPPORTS**

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.



### **3.4 PAINTING**

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

**END OF SECTION 26 0529**



**SECTION 26 0533**

**RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

**1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. IMC: Intermediate metal conduit.
- D. LFMC: Liquidtight flexible metal conduit.
- E. RSC/RGC/RMC: Rigid steel conduit / Rigid galvanized conduit/Rigid metal conduit.
- F. PVC/RNC: Polyvinylchloride / Rigid nonmetallic conduit.

**1.4 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

**PART 2 - PRODUCTS**

**2.1 METAL CONDUIT AND TUBING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. AFC Cable Systems, Inc.
  - 2. Alflec Inc.
  - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.

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4. Anamet Electrical, Inc.; Anaconda Metal Hose.
  5. Electri-Flex Co.
  6. Manhattan/CDT/Cole-Flex.
  7. Maverick Tube Corporation.
  8. O-Z Gedney; a unit of General Signal.
  9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. IMC: ANSI C80.6.
- D. EMT: ANSI C80.3.
- E. FMC: Zinc-coated steel or aluminum.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
  2. Fittings for EMT: Steel, set-screw or compression type.

## **2.2 NONMETALLIC CONDUIT AND TUBING**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
  2. Anamet Electrical, Inc.; Anaconda Metal Hose.
  3. CANTEX Inc.
  4. CertainTeed Corp.; Pipe & Plastics Group.
  5. Condux International, Inc.
  6. Electri-Flex Co.
  7. Lamson & Sessions; Carlon Electrical Products.
  8. Manhattan/CDT/Cole-Flex.
  9. RACO; Hubbell Co.
  10. Thomas & Betts Corp.
- B. RNC: NEMA TC2, Type EPC-40-PVC, unless otherwise indicated.

- C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

## **2.3 METAL WIREWAYS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Cooper B-Line, Inc.
  - 2. Hoffman.
  - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Screw-cover type unless specifically noted otherwise on the drawings.
- E. Finish: Manufacturer's standard enamel finish.

## **2.4 SURFACE RACEWAYS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Hubbell
  - 2. Panduit
  - 3. Thomas & Betts Corp.
  - 4. Wiremold Company; Legrand.
- B. Surface metal raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish color with final field applied paint color selected by Owner to match mounting surface.

## **2.5 BOXES, ENCLOSURES, AND CABINETS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
  - 2. EGS/Appleton Electric.
  - 3. Erickson Electrical Equipment Company.
  - 4. Hoffman.

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5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
  6. O-Z/Gedney; a unit of General Signal.
  7. RACO; a Hubbell Company.
  8. Robroy Industries, Inc.; Enclosure Division.
  9. Scott Fetzer Co.; Adalet Division.
  10. Spring City Electrical Manufacturing Company.
  11. Thomas & Betts Corporation.
  12. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- D. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

### **PART 3 - EXECUTION**

#### **3.1 RACEWAY APPLICATION**

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
1. Exposed Conduit: Rigid steel or IMC conduit.
  2. Concealed Conduit, Aboveground: RNC, Type EPC-40-PVC.
  3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Comply with the following indoor applications, unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
  2. Exposed, Not Subject to Severe Physical Damage: EMT.
  3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
  4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp, oily, or wet locations.
  5. Damp or Wet Locations: Rigid steel conduit or IMC.
  6. Raceways for Communications Cable in Spaces Used for Environmental Air: EMT.

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7. Raceways for Concealed General Purpose Distribution of Low-Voltage and Communications Cable: EMT.
  8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, nonmetallic in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

### **3.2 INSTALLATION**

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- E. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- F. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- G. Raceway Terminations at locations subject to moisture or vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- H. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- I. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
  1. Use LFMC in all damp or wet location applications in this scope of work where the conduit is exposed.

### **3.3 INSTALLATION OF UNDERGROUND CONDUIT**

- A. Direct-Buried Conduit:
  1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom for pipe less than 6 inches in nominal diameter.

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2. Install structural backfill, where not encased in concrete.
3. After installing conduit, backfill and compact. Start at tie-in point and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. Install continuous warning ribbon after 12" of backfill have been placed over the conduit. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with compaction equal to or greater than area being excavated.
4. Install manufactured duct elbows for stub-ups at equipment and at building entrances, unless otherwise indicated. Provide RGS factory elbows or concrete encase PVC elbows for stub-up ducts through the length of the elbow.

B. Concrete-Encased Conduit:

1. Provide conduit supports to allow concrete to flow around conduit without restriction.
2. Concrete around conduits containing medium voltage cables shall be tinted RED.
3. Provide continuous warning ribbon 12" above top of conduit(s). Provide second warning ribbon at 12" below final grade during backfill above concrete.

### 3.4 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

**END OF SECTION 26 0533**



**SECTION 26 0543**

**UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
  - 2. Rigid nonmetallic duct.
  - 3. Polymer concrete handholes and boxes with polymer concrete cover.
  - 4. Fiberglass handholes and boxes with polymer concrete cover.
  - 5. Fiberglass handholes and boxes.

**1.3 DEFINITIONS**

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
  - 1. Two or more ducts installed in parallel, with or without additional casing materials.
  - 2. Multiple duct banks.
- D. GRC/GSC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include duct-bank materials, including spacers and miscellaneous components.
  - 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.

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3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include underground-line warning tape.

B. Shop Drawings:

1. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
  - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include cover design.
  - d. Include grounding details.
  - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Duct and Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
  1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- D. Source quality-control reports.
- E. Field quality-control reports.

**1.6 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

**1.7 FIELD CONDITIONS**

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
  1. Notify Architect and Owner's representative no fewer than two weeks in advance of proposed interruption of electrical service.
  2. Do not proceed with interruption of electrical service without Architect's and Owner's written permission.

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- B. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.

## **PART 2 - PRODUCTS**

### **2.1 RIGID NONMETALLIC DUCT**

- A. Underground Plastic Utilities Duct: Type EPC-80-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. CANTEX INC.
  - 2. CertainTeed Corporation.
  - 3. Condux International, Inc.
  - 4. Electri-Flex Company.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

### **2.2 DUCT ACCESSORIES**

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems."

### **2.3 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER**

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armorcast Products Company.
  - 2. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.

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- E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC."
- I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

**2.4 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER**

- A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Armorcast Products Company.
  - 2. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC."
- I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## **2.5 FIBERGLASS HANDHOLES AND BOXES**

- A. Description: Molded of fiberglass-reinforced polyester resin, with covers made of polymer concrete.
- B. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC."
- I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain.

### **3.2 UNDERGROUND DUCT APPLICATION**

- A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.
- C. Underground Ducts Crossing Paved Paths, Walks, Driveways, Roadways: Type EPC-40 PVC RNC, encased in reinforced concrete.
- D. Stub-ups: Concrete-encased RNC.

### **3.3 UNDERGROUND ENCLOSURE APPLICATION**

- A. Handholes and Boxes for 600 V and Less:
  - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
  - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 Fiberglass enclosures with polymer concrete frame and cover or SCTE 77, Tier 15 Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 structural load rating.
  - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77 or Tier 8 structural load rating.
  - 4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
  - 5. Cover design load shall not exceed the design load of the handhole or box.

### **3.4 EARTHWORK**

- A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 73 00 "Execution."

### 3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches, both horizontally and vertically, at other locations unless otherwise indicated.
  - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. Terminator Entrances to Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

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- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- K. Pulling Cord: Install 200-lbf-test nylon cord in empty ducts.
- L. Concrete-Encased Ducts and Duct Bank:
  - 1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 20 00 "Earth Moving" for pipes less than 6 inches in nominal diameter.
  - 2. Width: Excavate trench 12 inches wider than duct on each side.
  - 3. Width: Excavate trench 3 inches wider than duct on each side.
  - 4. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
  - 5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
  - 6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
  - 7. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
  - 8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
  - 9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
    - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
    - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.



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- 1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
- c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
  - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
  - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
  - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 00 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 20 00 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
2. Width: Excavate trench 12 inches wider than duct on each side.
3. Width: Excavate trench 3 inches wider than duct on each side.
4. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.

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6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
  - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.
  - a. Place minimum 3 inches of sand as a bed for duct. Place sand to a minimum of 6 inches above top level of duct.
  - b. Place minimum 6 inches of engineered fill above concrete encasement of duct.
- N. Warning Planks: Bury warning planks approximately 12 inches above direct-buried duct, placing them 24 inches o.c. Align planks along the width and along the centerline of duct or duct bank.

Provide an additional plank for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional planks 12 inches apart, horizontally.

- O. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 05 53 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.

### **3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE**

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
  - 1. Concrete: 3000 psi, 28-day strength, complying with Section 03 30 00 "Cast-in-Place Concrete," with a troweled finish.

### **3.7 GROUNDING**

- A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

### **3.8 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:

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1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
  2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
  3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

**3.9 CLEANING**

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump.
1. Sweep floor, removing dirt and debris.
  2. Remove foreign material.

**END OF SECTION 26 0543**

**SECTION 26 0544**

**SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING**

**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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.

**1.3 ACTION SUBMITTALS**

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

**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.
- 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.
- C. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized sheet steel.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.

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- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## **2.2 SLEEVE-SEAL SYSTEMS**

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - 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.
    - e. Proco Products, Inc.
  - 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 3. Pressure Plates: Stainless steel.
  - 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

## **2.3 SLEEVE-SEAL FITTINGS**

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    - a. HOLDRITE.

## **2.4 GROUT**

- A. Description: Nonshrink; 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.

## **2.5 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.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

### **PART 3 - EXECUTION**

#### **3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS**

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
  4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated 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.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

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- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.
- G. 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.

### **3.2 SLEEVE-SEAL-SYSTEM INSTALLATION**

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. 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 that cause sealing elements to expand and make watertight seal.

### **3.3 SLEEVE-SEAL-FITTING INSTALLATION**

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

**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 the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Identification for raceway.
  - 2. Identification for conductors and communication and control cable.
  - 3. Equipment identification labels.
  - 4. Wiring device circuit identification labels.
  - 5. Miscellaneous identification products.

**1.3 QUALITY ASSURANCE**

- A. Comply with NFPA 70.
- B. Comply with 29 CFR 1910.145.

**1.4 COORDINATION**

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

**PART 2 - PRODUCTS**

**2.1 EQUIPMENT IDENTIFICATION LABELS**

- A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- B. See drawings for specific identification requirements for panelboards and related equipment.

**2.2 WIRING DEVICE LABELS**

- A. Embossed, clear adhesive tape, with 1/4" high black (depending on cover plate color selection) lettering with circuit number and panel identification for electrical devices (receptacles and switches). Labels shall be located on the face of the device cover plate, unless noted otherwise.

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- B. All labels shall be machine made and printed.

## **2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS**

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
1. Minimum Width: 3/16 inch.
  2. Tensile Strength: 50 lb, minimum.
  3. Temperature Range: Minus 40 to plus 185 deg F.
  4. Color: Black, except where used for color-coding.
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## **PART 3 - EXECUTION**

### **3.1 APPLICATION**

- A. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape marker tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.
- B. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.
- C. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
    - a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where 2 lines of text are required, use labels 2 inches high.
    - b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
  2. Equipment to Be Labeled:
    - a. Switchboards, Transformers, Panelboards, electrical cabinets, and enclosures.
    - b. Control devices.
    - c. Motor Controllers
    - d. Equipment safety disconnect switches
    - e. Equipment furnished by the Electrical Contractor

### 3.2 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification materials to surfaces that require finish after completing finish work.
- D. Conduit/raceway color system identification.
  - 1. System Identification Color for surface wireway: Each color band shall completely wrap outer portion of raceway cover. Place adjacent bands of multiple-color markings in contact, side by side, where wireway is used for more than one system. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
  - 2. System Identification Color for conduit:
    - a. Provide red colored conduit, where conduit is used for new fire alarm system cabling.
    - b. Provide blue colored conduit, where conduit is used for new or rerouted data system cabling.
    - c. Provide orange colored conduit for all new fiber optic cabling.
    - d. Provide white colored conduit, where conduit is used for new or rerouted control systems cabling.
- E. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
  - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
  - 2. Colors for 208/120-V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
  - 3. Colors for 480/277-V Circuits:
    - a. Phase A: Brown
    - b. Phase B: Orange
    - c. Phase C: Yellow
  - 4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

**END OF SECTION 26 0553**



**SECTION 26 0572**

**OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY**

**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 a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

**1.3 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Short-circuit study input data, including completed computer program input data sheets.
  - 2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

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- b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For Short-Circuit Study Software Developer.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

**1.6 QUALITY ASSURANCE**

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

**PART 2 - PRODUCTS**

**2.1 COMPUTER SOFTWARE**

- A. Comply with IEEE 399 and IEEE 551.
- B. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

**2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS**

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

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- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
  - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
  - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:
  - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Equivalent impedance.
  - 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Calculated asymmetrical fault currents:
      - 1) Based on fault-point X/R ratio.

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- 2) Based on calculated symmetrical value multiplied by 1.6.
  - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
- a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Obtain all data necessary for the conduct of the study.
1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
  2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Obtain electrical power utility impedance at the service.
  3. Power sources and ties.
  4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.



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6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
8. Motor horsepower and NEMA MG 1 code letter designation.
9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

### 3.2 **SHORT-CIRCUIT STUDY**

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
  1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
  1. Electric utility's supply termination point.
  2. Incoming switchgear.
  3. Unit substation primary and secondary terminals.
  4. Low-voltage switchgear.
  5. Control panels.
  6. Branch circuit panelboards.
  7. Disconnect switches.

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### **3.3 ADJUSTING**

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

### **3.4 DEMONSTRATION**

- A. Train Owner's operating and maintenance personnel in the use of study results.

**END OF SECTION 26 0572**

**SECTION 26 0573**

**OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY**

**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 computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 1. Study results shall be used to determine coordination of series-rated devices.

**1.3 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Coordination-study input data, including completed computer program input data sheets.
  - 2. Study and equipment evaluation reports.
  - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

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- a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

## **1.5 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For Coordination Study Software Developer.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

## **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. The following parts from the Protective Device Coordination Study Report:
      - 1) One-line diagram.
      - 2) Protective device coordination study.
      - 3) Time-current coordination curves.
    - b. Power system data.

## **1.7 QUALITY ASSURANCE**

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

## **PART 2 - PRODUCTS**

### **2.1 COMPUTER SOFTWARE DEVELOPERS**

- A. Software Developers:

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. CGI CYME.
  - b. EDSA Micro Corporation.
  - c. ESA Inc.
  - d. Operation Technology, Inc.
  - e. Power Analytics, Corporation.
  - f. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
  1. Optional Features:
    - a. Arcing faults.
    - b. Simultaneous faults.
    - c. Explicit negative sequence.
    - d. Mutual coupling in zero sequence.

## **2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS**

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  1. Protective device designations and ampere ratings.
  2. Cable size and lengths.
  3. Transformer kilovolt ampere (kVA) and voltage ratings.
  4. Motor designations and kVA ratings.
  5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.

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- E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 72 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study:
  - 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
    - a. Circuit Breakers:
      - 1) Adjustable pickups and time delays (long time, short time, ground).
      - 2) Adjustable time-current characteristic.
      - 3) Adjustable instantaneous pickup.
      - 4) Recommendations on improved trip systems, if applicable.
    - b. Fuses: Show current rating, voltage, and class.
- G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
  - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  - 4. Plot the following listed characteristic curves, as applicable:
    - a. Power utility's overcurrent protective device.
    - b. Medium-voltage equipment overcurrent relays.
    - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    - f. Cables and conductors damage curves.
    - g. Ground-fault protective devices.
    - h. Motor-starting characteristics and motor damage points.
    - i. The largest feeder circuit breaker in each motor-control center and panelboard.
  - 5. Series rating on equipment allows the application of two series interrupting devices for a condition where the available fault current is greater than the interrupting rating of the

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downstream equipment. Both devices share in the interruption of the fault and selectivity is sacrificed at high fault levels. Maintain selectivity for tripping currents caused by overloads.

6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
  1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

### **3.2 PROTECTIVE DEVICE COORDINATION STUDY**

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. Transformer Primary Overcurrent Protective Devices:
  1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

G. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

I. The calculations shall include the ac fault-current decay from induction motors, synchronous motors and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

J. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Branch circuit panelboards.

K. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

### 3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.



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2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

### **3.4 MOTOR-STARTING STUDY**

- A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

### **3.5 POWER SYSTEM DATA**

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
  1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
  2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Electrical power utility impedance at the service.
  3. Power sources and ties.
  4. Short-circuit current at each system bus, three phase and line-to-ground.
  5. Full-load current of all loads.
  6. Voltage level at each bus.
  7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.

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9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
11. Maximum demands from service meters.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
16. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Ratings, types, and settings of utility company's overcurrent protective devices.
  - e. Special overcurrent protective device settings or types stipulated by utility company.
  - f. Time-current-characteristic curves of devices indicated to be coordinated.
  - g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
  - h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
  - i. Panelboards, switchboards ampacity and SCCR in amperes rms symmetrical.
  - j. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### **3.6 FIELD ADJUSTING**

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

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- C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

**3.7 DEMONSTRATION**

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
  - 1. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
  - 2. Adjust, operate, and maintain overcurrent protective device settings.

**END OF SECTION 26 0573**



**SECTION 26 0574**

**OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY**

**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 a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

**1.3 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
  - 1. Arc-flash study input data, including completed computer program input data sheets.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For Arc-Flash Study Software Developer.
- B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

## **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data:
  - 1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
  - 2. Operation and Maintenance Procedures: In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

## **1.7 QUALITY ASSURANCE**

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
  - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

## **PART 2 - PRODUCTS**

### **2.1 COMPUTER SOFTWARE DEVELOPERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. CGI CYME.
  - 2. EDSA Micro Corporation.
  - 3. ESA Inc.
  - 4. Operation Technology, Inc.
  - 5. Power Analytics, Corporation.
  - 6. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

## **2.2 ARC-FLASH STUDY REPORT CONTENT**

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
  - 1. Protective device designations and ampere ratings.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 05 72 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 05 73 "Overcurrent Protective Device Coordination Study."
- G. Arc-Flash Study Output:
  - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. No AC Decrement (NACD) ratio.
    - e. Equivalent impedance.
    - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
  - 1. Arcing fault magnitude.
  - 2. Protective device clearing time.
  - 3. Duration of arc.
  - 4. Arc-flash boundary.
  - 5. Working distance.

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6. Incident energy.
  7. Hazard risk category.
  8. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

## **2.3 ARC-FLASH WARNING LABELS**

- A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
1. Location designation.
  2. Nominal voltage.
  3. Flash protection boundary.
  4. Hazard risk category.
  5. Incident energy.
  6. Working distance.
  7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

### **3.2 ARC-FLASH HAZARD ANALYSIS**

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Calculate maximum and minimum contributions of fault-current size.
1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
  2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.



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- C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- D. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- E. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- F. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
  - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
  - 2. Fault contribution from synchronous motors should be decayed to match the actual decrement of each as closely as possible.
- G. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
  - 1. When the circuit breaker is in a separate enclosure.
  - 2. When the line terminals of the circuit breaker are separate from the work location.
- H. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

### **3.3 POWER SYSTEM DATA**

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
  - 1. Verify completeness of data supplied on the one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
  - 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  - 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

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1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
11. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
14. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

### **3.4 LABELING**

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
  1. Low-voltage switchboard.
  2. Switchgear.
  3. Medium-voltage switch.
  4. Control panel.

### **3.5 APPLICATION OF WARNING LABELS**

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

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### **3.6 DEMONSTRATION**

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

**END OF SECTION 26 0574**



**SECTION 26 0923**

**LIGHTING CONTROL DEVICES**

**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. Standalone daylight-harvesting switching and dimming controls.
  - 2. Indoor occupancy and vacancy sensors.
  - 3. Switchbox-mounted occupancy sensors.
- B. Related Requirements:
  - 1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

**1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Show installation details for the following:
    - a. Occupancy sensors.
    - b. Vacancy sensors.
    - c. Photo sensors.
  - 2. Interconnection diagrams showing field-installed wiring.
  - 3. Include diagrams for power, signal, and control wiring.
  - 4. Plan drawings showing submitted manufacturer's device layout. Plans shall include device coverage patterns and shall provide supplemental devices for full coverage of areas indicated on bid documents. Bid documents are intended to indicate the areas of coverage and control, not the quantity and exact type of devices required for complete coverage, due to variations in manufacturers systems and devices.
  - 5. Submitted manufacturer shall create all submittal diagrams and plans.

#### **1.4 INFORMATIONAL SUBMITTALS**

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's warranties.

#### **1.5 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
  - 1. Software operating and upgrade manuals.
  - 2. Program Software Backup: On USB media. Provide names, versions, and website addresses for locations of installed software.
  - 3. Device address list.
  - 4. Printout of software application and graphic screens.

#### **1.6 WARRANTY**

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Faulty operation of lighting control software.
    - b. Faulty operation of lighting control devices.
  - 2. Warranty Period: Two year(s) from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### **2.1 DAYLIGHT-HARVESTING SWITCHING CONTROLS**

- A. System Description: System operates indoor lighting.
- B. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.
  - 1. Lighting control set point is based on two lighting conditions:
    - a. When no daylight is present.
    - b. When significant daylight is present (target level).
    - c. System programming is done with two hand-held, remote-control tools.

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- C. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with power pack, that detects changes in indoor lighting levels that are perceived by the eye.
- D. Electrical Components, Devices, and Accessories:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
  - 3. Sensor Output: Contacts rated to operate the associated power pack, complying with UL 773A. Sensor shall be powered by the power pack.
  - 4. Sensor Output: Digital signal compatible with power pack.
  - 5. Sensor type: Open loop.
  - 6. Zone: Single.
  - 7. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
    - a. LED status lights to indicate load status.
    - b. Plenum rated.
  - 8. Power Pack: Digital controller capable of accepting 3 RJ45 inputs with one output rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
    - a. With integral current monitoring
    - b. Compatible with digital addressable lighting interface.
    - c. Plenum rated.
  - 9. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
  - 10. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
  - 11. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
  - 12. Test Mode: User selectable, overriding programmed time delay to allow settings check.
  - 13. Control Load Status: User selectable to confirm that load wiring is correct.
  - 14. Indicator: Two digital displays to indicate the beginning of on-off cycles.

## **2.2 DAYLIGHT-HARVESTING DIMMING CONTROLS**

- A. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
  - 1. Lighting control set point is based on two lighting conditions:

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- a. When no daylight is present (target level).
  - b. When significant daylight is present.
- B. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate power pack, to detect changes in indoor lighting levels that are perceived by the eye.
- C. Electrical Components, Devices, and Accessories:
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
  - 3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc.
- D. Single-Circuit Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
  - 1. LED status lights to indicate load status.
  - 2. Plenum rated.
- E. Multi-Control Power Pack: Digital controller capable of accepting 3 RJ45 inputs with two outputs rated for 20-A LED load at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
  - 1. With integral current monitoring
    - a. Compatible with digital addressable lighting interface.
      - 1) Plenum rated.

## **2.3 INDOOR OCCUPANCY AND VACANCY SENSORS**

- A. General Requirements for Sensors:
  - 1. Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
  - 2. Dual technology.
  - 3. Separate power pack.
  - 4. Hardwired connection to switch.
  - 5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 6. Operation:
    - a. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.



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7. Sensor Output: Sensor is powered from the power pack.
  8. Power: Line voltage or Integral photovoltaic collector.
  9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
  10. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard outlet box.
    - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
  12. Bypass Switch: Override the "on" function in case of sensor failure.
  13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- B. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic or microphonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
  2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
  3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
  4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet when mounted 48 inches above finished floor.

## **2.4 SWITCHBOX-MOUNTED OCCUPANCY/VACANCY SENSORS**

- A. General Requirements for Sensors: Automatic-wall-switch occupancy/vacancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

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3. Vacancy Sensor Operation: Unless otherwise indicated, turn lights on by manual operation, turn lights off automatically when unoccupied; with time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
4. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
5. Switch Rating: Not less than 800-VA LED load at 120 V and 1200-VA LED load at 277 V.

## **2.5 CONDUCTORS AND CABLES**

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 SENSOR INSTALLATION**

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

### **3.3 WIRING INSTALLATION**

- A. Comply with NECA 1.

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- B. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### **3.4 IDENTIFICATION**

- A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

### **3.5 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Lighting control devices will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.6 ADJUSTING**

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
  - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

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2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

**3.7 DEMONSTRATION**

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control.
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

**END OF SECTION 26 0923**

## **SECTION 26 2200**

### **LOW-VOLTAGE TRANSFORMERS**

#### **PART 1 - GENERAL**

##### **1.1 SUMMARY**

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - 1. Distribution transformers.

##### **1.2 SUBMITTALS**

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 1. Power Wiring Diagrams.
- C. Source quality-control test reports.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

##### **1.3 QUALITY ASSURANCE**

- A. Source Limitations: Obtain each transformer 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 testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

##### **1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is

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not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

## **1.5 COORDINATION**

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. ABB
  - 2. Eaton Electrical Inc.; Cutler-Hammer Products.
  - 3. ELSCO (Electric Service Company)
  - 4. General Electric Company.
  - 5. Hammond Power Solutions
  - 6. Maddox Industrial Transformer
  - 7. Siemens Energy & Automation, Inc.
  - 8. Square D; Schneider Electric.

### **2.2 GENERAL TRANSFORMER REQUIREMENTS**

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
  - 1. Internal Coil Connections: Brazed or pressure type.
  - 2. Coil Material: Copper.

### **2.3 DISTRIBUTION TRANSFORMERS**

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Cores: One leg per phase.
- C. Enclosure: Ventilated, NEMA 250, Type 2.
  - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

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- D. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- E. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- F. Energy Efficiency for Transformers Rated 15 kVA and Larger:
  - 1. Complying with NEMA TP 1, Class 1 efficiency levels.
  - 2. Tested according to NEMA TP 2.
- G. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

## **2.4 IDENTIFICATION DEVICES**

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

## **2.5 SOURCE QUALITY CONTROL**

- A. Test and inspect transformers according to IEEE C57.12.91.

# **PART 3 - EXECUTION**

## **3.1 EXAMINATION**

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions.

### **3.3 CONNECTIONS**

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

### **3.5 ADJUSTING**

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

### **3.6 CLEANING**

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

**END OF SECTION 26 2200**



## **SECTION 26 2413**

### **SWITCHBOARDS**

#### **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. Service and distribution switchboards rated 600 V and less.
  - 2. Disconnecting and overcurrent protective devices.
  - 3. Accessory components and features.
  - 4. Identification.

##### **1.3 SUBMITTALS**

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
  - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
  - 6. Include evidence of NRTL listing for series rating of installed devices.
  - 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

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- C. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Routine maintenance requirements for switchboards and all installed components.
  - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

#### **1.4 QUALITY ASSURANCE**

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.

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

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards.
- C. Handle and prepare switchboards for installation according to NECA 400.

#### **1.6 PROJECT CONDITIONS**

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
  - 1. Do not deliver or install switchboards until wet work in spaces is complete and dry, and work above switchboards is complete.

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2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - a. Ambient Temperature: Not exceeding 104 deg F.
  - b. Altitude: Not exceeding 6600 feet.
- C. Service Conditions: NEMA PB 2, usual service conditions, as follows:
  1. Ambient temperatures within limits specified.
  2. Altitude not exceeding 6600 feet.
- D. Interruption of Existing Electric Service: 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:
  1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
  2. Indicate method of providing temporary electric service.
  3. Do not proceed with interruption of electric service without Owner's written permission.
  4. Comply with NFPA 70E.

## **1.7 COORDINATION**

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## **1.8 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Two years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURED UNITS**

- A. Basis-of-Design Product: Provide product indicated on Drawings.
- B. Front-Connected, Front-Accessible Switchboards:
  1. Main Devices: Panel mounted.
  2. Branch Devices: Panel mounted.

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- 3. Sections front and rear aligned.
- C. Nominal System Voltage: 480Y/277 V.
- D. Indoor Enclosures: Steel, NEMA 250, Type 1.
- E. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- F. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- G. Buses and Connections: Three phase, four-wire unless otherwise indicated.
  - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
  - 2. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
  - 3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  - 4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
  - 5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- H. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

## **2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.

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- d. Ground-fault pickup level, time delay, and  $I^2t$  response.
- 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
- 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
- 6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- 7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
- 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
  - a. Standard frame sizes, trip ratings, and number of poles.
  - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
  - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
  - d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- B. Insulated-Case Circuit Breaker (ICCB): 80 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
  - 1. Fixed circuit-breaker mounting.
  - 2. Standard-function, trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time time adjustments.
    - c. Ground-fault pickup level, time delay, and  $I^2t$  response.

## 2.3 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- B. Switchboard Device Nameplates: Label each feeder/branch circuit device in switchboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NECA 400.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

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- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install switchboards and accessories according to NECA 400.
- B. Equipment Mounting: Install switchboards on existing concrete floor.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- F. Install filler plates in unused spaces of panel-mounted sections.
- G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- H. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

### **3.4 FIELD QUALITY CONTROL**

- A. Acceptance Testing Preparation:

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1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
  2. Test continuity of each circuit.
- B. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  3. Perform the following infrared scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
    - c. Instruments and Equipment:
      - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Switchboard will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.5 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as indicated.

**END OF SECTION 26 2413**





**SECTION 26 2416**

**PANELBOARDS**

**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. Distribution panelboards.
  - 2. Lighting and appliance branch-circuit panelboards.

**1.3 SUBMITTALS**

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
  - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
  - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
  - 3. Detail bus configuration, current, and voltage ratings.
  - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - 6. Include wiring diagrams for power, signal, and control wiring.
- C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- D. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals.
  - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

#### **1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

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

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

#### **1.6 COORDINATION**

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

#### **1.7 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. Keys: Two spares for each type of panelboard cabinet lock.

### **PART 2 - PRODUCTS**

#### **2.1 GENERAL REQUIREMENTS FOR PANELBOARDS**

- A. Enclosures: Flush- and surface-mounted cabinets.
  - 1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

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2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
  3. Finishes:
    - a. Panels and Trim: Steel factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    - b. Back Boxes: Galvanized steel.
  4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- B. Incoming Mains Location: As required for each specific instance. Field verify prior to order.
- C. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
  2. Main and Neutral Lugs: Mechanical type.
  3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

## **2.2 DISTRIBUTION PANELBOARDS**

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: As indicated on the drawings.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

### **2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS**

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated on Drawings.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: As indicated on the drawings.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

### **2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- C. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install overcurrent protective devices and controllers not already factory installed.
- F. Install filler plates in unused spaces.

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- G. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- I. Comply with NECA 1.

### **3.3 IDENTIFICATION**

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads;
  - 1. Incorporate Owner's room designations. Obtain approval before installing.
  - 2. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
  - 3. Leave locations of spare breakers or panel spaces blank. Indicate spare breaker locations in pencil.
  - 4. For existing panelboards: Revise identification of breakers or switches to indicate modifications to loads, circuit uses, or to correct inaccuracies found.
  - 5. Directory circuit identifications shall comply with NEC 408.4. Panel schedules furnished on drawings shall not be considered sufficient.
- C. Spaces in new panelboards shall be identified as follows:
  - 1. Each single pole space shall have a separate identification.
  - 2. Example: The left side of a 42-space panelboard shall use odd numbers 1-41, in descending order, from top to bottom. The right side of the panelboard shall use even numbers 2-42, in descending order, from top to bottom.
  - 3. Multi-pole breakers or spaces shall use numbers from all spaces occupied (i.e. a 2-pole space or breaker shall be identified using both single pole spaces taken up). Multi-pole breakers and spaces shall not be identified using a single number.
  - 4. Circuits with emergency loads shall be marked with highlighter type marker.
  - 5. Circuits with fire alarm equipment loads shall have red handle lock device.
- D. Panelboard Nameplates:
  - 1. Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and in drawing details.
  - 2. Include power source on panelboard nameplate to satisfy requirement of NEC 408.4.
- E. Distribution Panelboard Device Nameplates:
  - 1. Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and in drawing details.

2. Include power source on panelboard nameplate to satisfy requirement of NEC 408.4.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
  1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
  2. Test continuity of each circuit.
- C. Tests and Inspections:
  1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### **3.5 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
  1. Measure as directed during period of normal system loading.
  2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
  3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
  4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

**END OF SECTION 26 2416**

**SECTION 26 2726**

**WIRING DEVICES**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
  - 2. Wall-switch and exterior occupancy sensors.

**1.3 DEFINITIONS**

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

**1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Samples: When requested during product submittals, furnish one of each type of device and wall plate requested, in each color requested.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

**1.5 QUALITY ASSURANCE**

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

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- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

## **1.6 COORDINATION**

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
  - 1. Cord and Plug Sets: Match equipment requirements.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers' Names: As indicated on the drawings.

### **2.2 STRAIGHT BLADE RECEPTACLES**

- A. Convenience Receptacles, Specification Grade 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

### **2.3 GFCI RECEPTACLES**

- A. General Description: Specification grade Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

### **2.4 SNAP SWITCHES**

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:

### **2.5 WALL PLATES**

- A. Single and combination types to match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Unfinished Spaces: Galvanized steel.
  - 3. Material for Wet Locations: Thermoplastic or cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."



## **2.6 FINISHES**

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
  - 1. Wiring Devices: Reference Material Schedule on drawings and provide devices and device cover plates in manufacturer's standard colors, as selected by Architect.
  - 2. Minimum color selections: Black, Gray, White, Ivory, Light Almond, Red.

## **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. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
  - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
  - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
  - 4. Existing Conductors:
    - 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. Device Installation:
  - 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

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2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### 3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use machine lettered black, minimum 1/8" letters with a clear background on face of plate, and durable wire markers or tags inside outlet boxes.

### 3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

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B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

**END OF SECTION 26 2726**



## **SECTION 26 2813**

### **FUSES**

#### **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. Cartridge fuses rated 600 V ac and less for use in the following:
  - a. Control circuits.
  - b. Switchboards.
  - c. Enclosed controllers.
  - d. Enclosed switches.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
  - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
    - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
  - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
  - 3. Current-limitation curves for fuses with current-limiting characteristics.
  - 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit [in electronic format suitable for use in coordination software] and in PDF format.
  - 5. Coordination charts and tables and related data.
  - 6. Fuse sizes for elevator feeders and elevator disconnect switches.

#### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 77 00 "Closeout Procedures," Section 01 78 23 "Operation and Maintenance Data," include the following:
  - 1. Ambient temperature adjustment information.
  - 2. Current-limitation curves for fuses with current-limiting characteristics.
  - 3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
  - 4. Coordination charts and tables and related data.

#### **1.5 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

#### **1.6 FIELD CONDITIONS**

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

### **PART 2 - PRODUCTS**

#### **2.1 CARTRIDGE FUSES**

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
  - 1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  - 2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  - 3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
  - 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 FUSE APPLICATIONS**

- A. Cartridge Fuses:
  - 1. Feeders: Class L, time delay.
  - 2. Motor Branch Circuits: Class RK1, time delay.
  - 3. Large Motor Branch (601-4000 A): Class L, time delay.
  - 4. Other Branch Circuits: Class RK1, time delay.

### **3.3 INSTALLATION**

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect and Owner.

### **3.4 IDENTIFICATION**

- A. Install labels complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

**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 the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Nonfusible switches.
  - 3. Molded-case circuit breakers (MCCBs).
  - 4. Enclosures.

**1.3 DEFINITIONS**

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
  - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
  - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.
- B. Shop Drawings: For enclosed switches and circuit breakers.
  - 1. Include plans, elevations, sections, details, and attachments to other work.

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2. Include wiring diagrams for power, signal, and control wiring.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
  1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
    - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  2. Fuse Pullers: Two for each size and type.

#### 1.7 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
  2. Altitude: Not exceeding 6600 feet.

#### 1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: One year from date of Substantial Completion.

### PART 2 - PRODUCTS

#### 2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Contractor shall verify existing condition dimensions prior to product submittal. Comply with indicated maximum dimensions.

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- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

## 2.2 FUSIBLE SWITCHES

- A. Type HD, Heavy Duty:
  - 1. Single throw.
  - 2. Three pole.
  - 3. 600-V ac.
  - 4. 1200 A and smaller.
  - 5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
  - 6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.
- B. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  - 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
  - 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
  - 6. Lugs: Mechanical type, suitable for number, size, and conductor material.
  - 7. Service-Rated Switches: Labeled for use as service equipment.

## 2.3 NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Two or Three Pole, Single Throw, 600-V ac or 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- B. Accessories:
  - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  - 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120-V ac.
  - 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
  - 6. Lugs: Mechanical type, suitable for number, size, and conductor material.

## 2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breaker/circuit breaker or Fuse/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. \_\_\_\_\_ Amps Available. Identical Replacement Component Required."
- D. MCCBs shall be equipped with a device for locking in the isolated position.
- E. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.
- F. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- G. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
  - 1. Instantaneous trip.
  - 2. Long- and short-time pickup levels.
  - 3. Long- and short-time time adjustments.
  - 4. Ground-fault pickup level, time delay, and I-squared t response.
- J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- K. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

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- L. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- M. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- N. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.
  - 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
  - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

## **2.5 ENCLOSURES**

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be [finished with] gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R, 12).
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
  - 1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

### **3.2 PREPARATION**

- A. Interruption of Existing Electric Service: 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:
  - 1. Notify Architect and Owner no fewer than two weeks in advance of proposed interruption of electric service.
  - 2. Indicate method of providing temporary electric service.
  - 3. Do not proceed with interruption of electric service without Architect's and Owner's written permission.

4. Comply with NFPA 70E.

### 3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
  1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  2. Outdoor Locations: NEMA 250, Type 3R .
  3. Kitchen Pool Areas: NEMA 250, Type 4X, stainless steel.
  4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

### 3.4 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NFPA 70 and NECA 1.

### 3.5 IDENTIFICATION

- A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."
  1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  2. Label each enclosure with engraved metal or laminated-plastic nameplate.

### 3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections for Switches:
  1. Visual and Mechanical Inspection:
    - a. Inspect physical and mechanical condition.
    - b. Inspect anchorage, alignment, grounding, and clearances.
    - c. Verify that the unit is clean.
    - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.

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- e. Verify that fuse sizes and types match the Specifications and Drawings.
- f. Verify that each fuse has adequate mechanical support and contact integrity.
- g. Inspect bolted electrical connections for high resistance using one of the two following methods:
  - 1) Use a low-resistance ohmmeter.
    - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
    - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

C. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

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- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
  - b. Inspect physical and mechanical condition.
  - c. Inspect anchorage, alignment, grounding, and clearances.
  - d. Verify that the unit is clean.
  - e. Operate the circuit breaker to ensure smooth operation.
  - f. Inspect bolted electrical connections for high resistance using one of the two following methods:
    - 1) Use a low-resistance ohmmeter.
      - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
  - g. Inspect operating mechanism, contacts, and chutes in unsealed units.
  - h. Perform adjustments for final protective device settings in accordance with the coordination study.
2. Electrical Tests:
- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
  - b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
  - c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
  - d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
  - e. Determine the following by primary current injection:



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- 1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
  - 4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  4. Perform the following infrared scan tests and inspections and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
1. Test procedures used.
  2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
  3. List deficiencies detected, remedial action taken, and observations after remedial action.

### **3.7 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.

**END OF SECTION 26 2816**



**SECTION 26 2913**

**ENCLOSED CONTROLLERS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:
  - 1. Across-the-line, manual and magnetic controllers.

**1.2 SUBMITTALS**

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
  - 1. 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.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
  - 1. Routine maintenance requirements for enclosed controllers and all installed components.
- E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

**1.3 QUALITY ASSURANCE**

- A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

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- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

#### **1.4 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 controllers; install electric heating of sufficient wattage to prevent condensation.

#### **1.5 PROJECT CONDITIONS**

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
  - 2. Indicate method of providing temporary utilities.
  - 3. Do not proceed with interruption of electrical service without Construction Manager's written permission.

#### **1.6 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.

## **PART 2 - PRODUCTS**

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

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
  - 1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.
- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.
  - 1. Control Circuit: 120 V or 24 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. Control voltage shall be verified with temperature controls system contractor prior to ordering.
  - 2. Overload: Bi-metal sized based on the motor nameplate the device is protecting.

### **2.2 ENCLOSURES**

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250.
  - 1. Type 1 enclosure for typical indoor installations
  - 2. Type 12 enclosure for typical indoor installations where mounted adjacent to pumps, boilers, or other fluid containing equipment or environments of high dirt or grease/oil concentrations.
  - 3. Type 3R enclosure for typical exterior installations.
  - 4. Type 4X enclosure for typical washdown areas or corrosive atmosphere.

### **2.3 ACCESSORIES**

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

### **2.4 FACTORY FINISHES**

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

## **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.

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### **3.2 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.

### **3.3 IDENTIFICATION**

- A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

**END OF SECTION 26 2913**

**SECTION 26 2923**

**VARIABLE-FREQUENCY MOTOR CONTROLLERS**

**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 separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
- B. Related Requirements:
  - 1. Section 26 24 19 "Motor-Control Centers" for VFCs installed in motor-control centers.

**1.3 DEFINITIONS**

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformer.
- C. DDC: Direct digital control.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type and rating of VFC indicated.
  - 1. Include dimensions and finishes for VFCs.

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2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  3. Include manufacturer required/recommended clearances above and around VFCs. Indicate maximum and minimum dimensions for VFCs, including clearances between VFCs and adjacent surfaces and other items
- B. Shop Drawings: For each VFC indicated.
1. Include mounting and attachment details.
  2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  3. Include diagrams for power, signal, and control wiring.
  4. Include manufacturer installation information.

### **1.5 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Required working clearances and required area above and around VFCs.
  2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
  3. Show support locations, type of support, and weight on each support.
  4. Indicate field measurements.
- B. Product Certificates: For each VFC from manufacturer.

### **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
    - b. Manufacturer's written instructions for setting field-adjustable overload relays.
    - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
    - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
    - e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.



## **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
  - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
  - 3. Indicating Lights: Two of each type and color installed.
  - 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
  - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

## **1.8 QUALITY ASSURANCE**

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
  - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

## **1.10 WARRANTY**

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Five years from date of Substantial Completion.

# **PART 2 - PRODUCTS**

## **2.1 SYSTEM DESCRIPTION**

- A. General Requirements for VFCs:
  - 1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.
- B. Application: Constant torque and variable torque.
- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as

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a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
  2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
  3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 100 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
  2. Input AC Voltage Unbalance: Not exceeding 3 percent.
  3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
  4. Minimum Efficiency: 96 percent at 60 Hz, full load.
  5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
  6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
  7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F. Maximum ambient operating temperature shall be at least 120 deg F, with proportional derating.
  8. Humidity Rating: Less than 95 percent (noncondensing).
  9. Altitude Rating: Not exceeding 3300 feet.
  10. Vibration Withstand: Comply with NEMA ICS 61800-2.
  11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
  12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
  13. Speed Regulation: Plus or minus 5 percent.
  14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
  15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
  16. Operational position: Capable of normal operation +10° from vertical.
- G. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
- H. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
  2. Maximum Speed: 80 to 120 percent of maximum rpm.

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3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses UL 489, thermal-magnetic circuit breaker NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses NEMA KS 1 or fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. NC and NO alarm contacts that operate only when circuit breaker has tripped.

## 2.2 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
  - 1. Power on.
  - 2. Run.
  - 3. Overvoltage.
  - 4. Line fault.
  - 5. Overcurrent.
  - 6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
  - 1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
  - 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
    - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
  - 1. Real-time clock with current time and date.
  - 2. Running log of total power versus time.
  - 3. Total run time.
  - 4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display[ and additional readout devices as required,] mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
  - 1. Output frequency (Hz).
  - 2. Motor speed (rpm).
  - 3. Motor status (running, stop, fault).
  - 4. Motor current (amperes).
  - 5. Motor torque (percent).
  - 6. Fault or alarming status (code).
  - 7. PID feedback signal (percent).
  - 8. DC-link voltage (V dc).
  - 9. Set point frequency (Hz).
  - 10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
  - 1. Electric Input Signal Interface:

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- a. A minimum of two programmable analog inputs: 0- to 10-V dc, 4- to 20-mA dc and Operator-selectable "x"- to "y"-mA dc.
  - b. A minimum of six multifunction programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
  - a. 0- to 10-V dc.
  - b. 4- to 20-mA dc.
  - c. Potentiometer using up/down digital inputs.
  - d. Fixed frequencies using digital inputs.
4. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc, 4- to 20-mA dc and operator-selectable "x"- to "y"-mA dc), which can be configured for any of the following:
  - a. Output frequency (Hz).
  - b. Output current (load).
  - c. DC-link voltage (V dc).
  - d. Motor torque (percent).
  - e. Motor speed (rpm).
  - f. Set point frequency (Hz).
5. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
  - a. Motor running.
  - b. Set point speed reached.
  - c. Fault and warning indication (overtemperature or overcurrent).
  - d. PID high- or low-speed limits reached.
- F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
  1. Number of Loops: One.
- G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
  1. Hardwired Points:
    - a. Monitoring: On-off status.
    - b. Control: On-off operation.
  2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for

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HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

3. Furnish an integral communications card capable of interface directly with the BAS system.

## 2.3 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.
- B. Output Filtering: 3%.
- C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

## 2.4 BYPASS SYSTEMS

- A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
- B. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.
- C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.
  1. Bypass Contactor: Load-break, IEC-rated contactor.
  2. Input and Output Isolating Contactors: Non-load-break, IEC-rated contactors.
  3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
- D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.
  1. NORMAL/BYPASS selector switch.
  2. HAND/OFF/AUTO selector switch.
  3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
  4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    - b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

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5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT control power source of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
  - a. CPT Spare Capacity: 100 VA.
6. Overload Relays: NEMA ICS 2.
  - a. Solid-State Overload Relays:
    - 1) Switch or dial selectable for motor-running overload protection.
    - 2) Sensors in each phase.
    - 3) Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - 5) Analog communication module.
  - b. NC and NO isolated overload alarm contact.
  - c. External overload, reset push button.

## 2.5 OPTIONAL FEATURES

- A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.
- B. Provide separate output overload contactors for each motor.
  1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
- C. Damper control circuit with end-of-travel feedback capability.
- D. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
- E. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
- F. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- G. Remote digital operator kit.
- H. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

## 2.6 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

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1. Dry and Clean Indoor Locations: Type 1.
  2. Kitchen Areas: Type 4X, stainless steel.
  3. Other Wet or Damp Indoor Locations and Outdoor Locations: Type 3R or 4X.
  4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

## **2.7 ACCESSORIES**

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
1. Push Buttons: Covered.
  2. Pilot Lights: Push to test.
  3. Selector Switches: Digital interface type.
  4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- B. Reversible NC/NO bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- E. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 Type 4X and Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- F. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R Type 4X and Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- G. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.
- H. Spare control-wiring terminal blocks; unwired.

## **2.8 SOURCE QUALITY CONTROL**

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.



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1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
  2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### **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 of the Work.
- 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. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 05 29 "Hangers and Supports for Electrical Systems."
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."
- D. Comply with NECA 1.

#### **3.3 CONTROL WIRING INSTALLATION**

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."

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- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
  - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
  - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

### **3.4 IDENTIFICATION**

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each VFC with engraved nameplate.
  - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

### **3.5 FIELD QUALITY CONTROL**

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. 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 Owner before starting the motor(s).
  - 5. Test each motor for proper phase rotation.
  - 6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - 8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
    - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.

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- b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
  - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
- 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. VFCs will be considered defective if they do not pass tests and inspections.
- D. 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 checks 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. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect and Owner before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers.
- E. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

### **3.8 PROTECTION**

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

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### **3.9 DEMONSTRATION**

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

**END OF SECTION 26 2923**

**SECTION 26 4313**

**TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS**

**PART 1 - GENERAL**

**1.1 SUMMARY**

- A. This Section includes TVSSs for low-voltage power equipment.

**1.2 DEFINITIONS**

- A. ATS: Acceptance Testing Specifications.
- B. SPD: Surge Protection Device.
- C. SVR: Suppressed voltage rating.
- D. TVSS: Transient voltage surge suppressor.

**1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, operating characteristics, furnished specialties, and accessories.
- B. Product Certificates: For transient voltage suppression devices, signed by product manufacturer certifying compliance with the following standards:
  - 1. UL 1283.
  - 2. UL 1449.
- C. Operation and Maintenance Data: For transient voltage suppression devices to include in emergency, operation, and maintenance manuals.
- D. Warranties: Special warranties specified in this Section.

**1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, dimensional requirements, and electrical performance of suppressors and are based on the specific system indicated.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

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- D. Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits."
- E. Comply with NEMA LS 1, "Low Voltage Surge Protection Devices."
- F. Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

## **1.5 PROJECT CONDITIONS**

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without the Architect and Owner's written permission.
- B. Service Conditions: Rate surge protection devices for continuous operation under the following conditions, unless otherwise indicated:
  - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
  - 2. Operating Temperature: 30 to 120 deg F.
  - 3. Humidity: 0 to 85 percent, noncondensing.
  - 4. Altitude: Less than 20,000 feet above sea level.

## **1.6 WARRANTY**

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within five years from date of Substantial Completion.

## **1.7 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Replaceable Protection Modules: One of each size and type installed.

## **PART 2 - PRODUCTS**

### **2.1 SERVICE ENTRANCE AND DISTRIBUTION PANEL SUPPRESSORS**

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:

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1. LED indicator lights for power and protection status.
  2. Audible alarm, with silencing switch, to indicate when protection has failed.
  3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:
1. Fabrication using bolted compression lugs for internal wiring.
  2. Integral disconnect switch.
  3. Redundant suppression circuits.
  4. Redundant replaceable modules.
  5. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
  6. LED indicator lights for power and protection status.
  7. Audible alarm, with silencing switch, to indicate when protection has failed.
  8. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
  9. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 240 kA per phase.
- D. Connection Means: Permanently wired.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120.
  2. Line to Ground: 400 V for 208Y/120.
  3. Neutral to Ground: 400 V for 208Y/120.

## **2.2 BRANCH CIRCUIT PANEL SUPPRESSORS**

- A. Surge Protection Device Description: Non-modular, sine-wave-tracking type with the following features and accessories:
1. LED indicator lights for power and protection status.
  2. Audible alarm, with silencing switch, to indicate when protection has failed.
  3. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
- B. Surge Protection Device Description: Modular design with field-replaceable modules, sine-wave-tracking type with the following features and accessories:

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1. Fabrication using bolted compression lugs for internal wiring.
  2. Integral disconnect switch.
  3. Redundant suppression circuits.
  4. Redundant replaceable modules.
  5. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
  6. LED indicator lights for power and protection status.
  7. Audible alarm, with silencing switch, to indicate when protection has failed.
  8. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Coordinate with building power monitoring and control system.
  9. Surge-event operations counter.
- C. Peak Single-Impulse Surge Current Rating: 120 kA per phase.
- D. Connection Means: Permanently wired.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120V, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120.
  2. Line to Ground: 400 V for 208Y/120.
  3. Neutral to Ground: 400 V for 208Y/120.
- F. Protection modes and UL 1449 SVR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 400 V for 208Y/120.
  2. Line to Ground: 400 V for 208Y/120.
  3. Neutral to Ground: 400 V for 208Y/120.

## **2.3 ENCLOSURES**

- A. Factory installed, integral to the panel or device being protected, where indicated.
- B. NEMA 1, NEMA 3R, NEMA 4X, NEMA 12, for remote installed surge protection device, according to environmental conditions.



### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION OF SURGE PROTECTION DEVICES**

- A. Install devices at service entrance on load side, with ground lead bonded to service entrance ground.

#### **3.2 PLACING SYSTEM INTO SERVICE**

- A. Do not energize or connect service entrance equipment to their sources until surge protection devices are installed and connected.

#### **3.3 FIELD QUALITY CONTROL**

- A. Testing: Perform the following field tests and inspections and prepare test reports:
  - 1. After installing SPD, but before electrical circuitry has been energized, test for compliance with requirements.
  - 2. Complete startup checks according to manufacturer's written instructions.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
- B. Remove and replace malfunctioning units and retest as specified above.

#### **3.4 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transient voltage suppression devices.

**END OF SECTION 26 4313**



**SECTION 26 5119**  
**LED INTERIOR LIGHTING**

**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. Interior solid-state luminaires that use LED technology.
  - 2. Lighting fixture supports.
- B. Related Requirements:
  - 1. Section 26 09 23 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

**1.3 DEFINITIONS**

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Arrange in order of luminaire designation.
  - 2. Include data on features, accessories, and finishes.
  - 3. Include physical description and dimensions of luminaires.
  - 4. Include emergency lighting units, including batteries and chargers.

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5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.
  - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Product Schedule: For luminaires: Use same designations indicated on Drawings.

#### **1.5 INFORMATIONAL SUBMITTALS**

- A. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of luminaire.
- C. Product Test Reports: For each luminaire, for tests performed by [manufacturer and witnessed by a qualified testing agency] [a qualified testing agency].
- D. Sample warranty.

#### **1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
  1. Provide a list of all fixture types used on Project; use ANSI and manufacturers' codes.

#### **1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. LED Drivers: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
  2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

#### **1.8 QUALITY ASSURANCE**

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Provide luminaires from a single manufacturer for each luminaire type.

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

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

## **1.10 WARRANTY**

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) parts and labor from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

### **2.2 LUMINAIRE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. Recessed Fixtures: Comply with NEMA LE 4.
- D. CRI of minimum 80. CCT at 4000 K.
- E. Minimum Rated light engine life of 70% light output at 70,000 hours, unless otherwise indicated on Luminaire Schedule description and basis of design model number.
- F. Luminaires dimmable from 100 percent to 1 percent of maximum light output unless specifically noted otherwise.
- G. Internal driver.
- H. Nominal Operating Voltage: 120 V and 277 V ac.
  - 1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- I. Housings:
  - 1. Extruded or cast-aluminum housing and heat sink.
  - 2. Clear anodized, powder-coat or painted finish as noted.

### **2.3 DOWNLIGHT**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Universal mounting bracket.
- C. Integral junction box with conduit fittings.

### **2.4 LINEAR INDUSTRIAL**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.

### **2.5 RECESSED LINEAR**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Integral junction box with conduit fittings.

### **2.6 STRIP LIGHT**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Integral junction box with conduit fittings.

### **2.7 SURFACE MOUNT, LINEAR**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Integral junction box with conduit fittings.

### **2.8 SURFACE MOUNT, NONLINEAR**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Integral junction box with conduit fittings.

### **2.9 SUSPENDED, LINEAR**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.

## **2.10 SUSPENDED, NONLINEAR**

- A. Minimum lumens and minimum allowable efficacy (lumens per watt) as defined in luminaire schedule or as indicated by basis of design model.
- B. Integral junction box with conduit fittings.

## **2.11 MATERIALS**

- A. Metal Parts:
  - 1. Free of burrs and sharp corners and edges.
  - 2. Sheet metal components shall be steel unless otherwise indicated.
  - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit complete repair without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during repair and when secured in operating position.
- C. Diffusers and Globes:
  - 1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
  - 2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- D. Driver Housings:
  - 1. Extruded or cast-aluminum housing and heat sink.
- E. Fixture Housings:
  - 1. Clear anodized, powder-coat or painted finish as noted on the schedule.
- F. Factory-Applied Labels: Comply with UL 1598. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
  - 1. Label shall include the following lamp characteristics:
    - a. "USE ONLY" and include specific lamp type.
    - b. CCT and CRI for all luminaires.

## **2.12 METAL FINISHES**

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

### **2.13 LUMINAIRE FIXTURE SUPPORT COMPONENTS**

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch threaded steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 TEMPORARY LIGHTING**

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting.

### **3.3 INSTALLATION**

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Supports:
  - 1. Sized and rated for luminaire weight.
  - 2. Able to maintain luminaire position after cleaning and repair.
  - 3. Provide support for luminaire without causing deflection of ceiling or wall.
  - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.
- D. Flush-Mounted Luminaire Support:



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1. Secured to outlet box.
  2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
  3. Trim ring flush with finished surface.
- E. Wall-Mounted Luminaire Support:
1. Attached to structural members in walls.
  2. Do not attach luminaires directly to gypsum board.
- F. Ceiling-Mounted Luminaire Support:
1. Ceiling mount with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length, unless otherwise required by particular installation conditions.
- G. Suspended Luminaire Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
  2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
  3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing, rod or wire support for suspension for each unit length of luminaire chassis, including one at each end.
  4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- H. Ceiling-Grid-Mounted Luminaires:
1. Secure to any required outlet box.
  2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
  3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
  4. Connect to associated above-ceiling outlet box with flexible whip, less than 6'-0" in length to allow placement adjustment to each adjacent ceiling grid spaces.
- I. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

### **3.4 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

### **3.5 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
  - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

### **3.6 ADJUSTING**

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
  - 1. During adjustment visits, inspect all luminaires. Replace drivers or luminaires that are defective.
  - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
  - 3. Adjust the aim of luminaires in the presence of the Architect.

**END OF SECTION 26 5119**

**SECTION 26 5219**

**EMERGENCY AND EXIT LIGHTING**

**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. Emergency lighting units.
  - 2. Exit signs.
  - 3. Luminaire supports.

**1.3 DEFINITIONS**

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including light source, driver, reflector, and housing.

**1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
  - 1. Include data on features, accessories, and finishes.
  - 2. Include physical description of the unit and dimensions.
  - 3. Battery and charger for light units.
  - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
  - 5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

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- a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom luminaires.
  - 1. Include plans, elevations, sections, and mounting and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include diagrams for power, signal, and control wiring.
- C. Samples: For each product and for each color and texture specified.
- D. Samples for Initial Selection: For each type of luminaire with factory-applied finishes.
- E. Product Schedule:
  - 1. For emergency lighting units. Use same designations indicated on Drawings.
  - 2. For exit signs. Use same designations indicated on Drawings.

**1.5 INFORMATIONAL SUBMITTALS**

- A. Product Certificates: For each type of luminaire.
- B. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.
- C. Sample Warranty: For manufacturer's warranty.

**1.6 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.
  - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

**1.7 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Luminaires: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 2. LED Drivers: 10 for every 100 of each type and rating installed. Furnish at least one of each type.

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3. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
4. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
5. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

## **1.8 QUALITY ASSURANCE**

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. FM Global Compliance: luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

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

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

## **1.10 WARRANTY**

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: Five year(s) from date of Substantial Completion.
- B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
  1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for [first year and prorated warranty for the remaining four years] [the entire warranty period].

## **PART 2 - PRODUCTS**

### **2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.

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- D. Comply with NEMA LE 4 for recessed luminaires.
- E. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.
  - 1. Emergency Connection: Operate luminaire continuously at an output of 1400 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire driver.
  - 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
  - 3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
    - b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
    - c. Humidity: More than 95 percent (condensing).
    - d. Altitude: Exceeding 3300 feet.
  - 4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
  - 5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
    - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
  - 6. Battery: Sealed, maintenance-free, nickel-cadmium type.
  - 7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
- F. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.
  - 1. Emergency Connection: Operate one LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
  - 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
  - 3. Nightlight Connection: Operate lamp in a remote luminaire continuously.

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4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type.
6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the LED driver and emergency power unit manufacturer, whichever is less.
7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

## 2.2 SELF-CONTAINED EMERGENCY LIGHTING

- A. General Requirements for Emergency Lighting Units: Self-contained units.
- B. Emergency luminaires:
  1. Emergency luminaires: as indicated on Luminaire Schedule and Drawings, with the following additional features:
    - a. Operating at nominal voltage of 120 V ac and 277 V ac.
    - b. Internal emergency power unit.
    - c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.
    - d. UL 94 5VA flame rating.
- C. Emergency Lighting Unit:
  1. Emergency Lighting Unit: as indicated on Luminaire Schedule and the Drawings.
  2. Operating at nominal voltage of 120 V ac and 277 V ac.
  3. Wall with universal junction box adaptor.
  4. UV stable thermoplastic housing.
  5. Two LED lamp heads.
  6. Internal emergency power unit.

## 2.3 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
  1. Operating at nominal voltage of 120 V and ac 277 V ac.
  2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
  3. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

## **2.4 MATERIALS**

### **A. Metal Parts:**

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

### **B. Doors, Frames, and Other Internal Access:**

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit repair without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during repair and when secured in operating position.

### **C. Diffusers and Globes:**

1. Glass: Annealed crystal glass unless otherwise indicated.
2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Lens Thickness: At least 0.187 inch minimum unless otherwise indicated.

### **D. Housings:**

1. Extruded aluminum housing and heat sink.
2. Clear anodized, powder or coat painted finish as noted on the drawings.

## **2.5 METAL FINISHES**

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## **2.6 LUMINAIRE SUPPORT COMPONENTS**

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.



## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

### **3.3 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections:
  - 1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

### **3.5 STARTUP SERVICE**

- A. Perform startup service:
  - 1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.

### **3.6 ADJUSTING**

- A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

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1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.
  - a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.
3. Adjust aiming of adjustable head emergency units for proper path of egress coverage.

**END OF SECTION 26 5219**

**SECTION 27 0528**

**PATHWAYS FOR COMMUNICATIONS SYSTEMS**

**PART 1 - GENERAL**

**1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduits and fittings.
  - 2. Hooks.
  - 3. Boxes, enclosures, and cabinets.

**1.3 DEFINITIONS**

- A. GRC: Galvanized rigid conduit.
- B. IMC: Intermediate metal conduit.
- C. EMT: Electrical metallic tubing

**1.4 ACTION SUBMITTALS**

- A. Product data for the following:
  - 1. Surface pathways
  - 2. Wireways and fittings.
  - 3. Boxes, enclosures, and cabinets.

**PART 2 - PRODUCTS**

**2.1 METAL CONDUITS AND FITTINGS**

- A. Refer to Section 26 05 33 – Raceway and Boxes for Electrical Systems.
- B. Refer to Section 26 05 53 – Identification for Electrical Systems

## **2.2 METAL WIREWAYS AND AUXILIARY GUTTERS**

- A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.
- B. General Requirements for Metal Wireways and Auxiliary Gutters:
  - 1. Comply with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
  - 2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
  - 3. Comply with TIA-569-C.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

## **2.3 SURFACE METAL PATHWAYS**

- A. Description: Galvanized steel with snap-on covers, complying with UL 5.
- B. Finish: Manufacturer's standard enamel finish in color selected by Architect.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-C.

## **2.4 HOOKS**

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-C.
- D. Galvanized steel.
- E. J shape.

## **2.5 BOXES, ENCLOSURES, AND CABINETS**

- A. Refer to Section 26 05 33 – Raceway and Boxes for Electrical Systems.

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- B. General Requirements for Boxes, Enclosures, and Cabinets:
  - 1. Comply with TIA-569-C.
  - 2. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
  - 3. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
  - 4. Gangable boxes are prohibited.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- F. Cabinets:
  - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Accessory feet where required for freestanding equipment.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
  - 1. NECA 1.
  - 2. NECA/BICSI 568.
  - 3. TIA-569-C.
  - 4. NECA 101
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

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- C. Comply with requirements in Section 27 05 28.29 "Hangers and Supports for Communications Systems" for hangers and supports.
- D. Comply with requirements in Section 27 05 44 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.
- E. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- F. Complete pathway installation before starting conductor installation.
- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- H. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- J. Support conduit within 12 inches of enclosures to which attached.
- K. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for pathways.
  - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- O. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- P. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- Q. Pathways for Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
  - 1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
  - 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.

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3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- R. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.
- S. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
  1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where an underground service pathway enters a building or structure.
  3. Where otherwise required by NFPA 70.
- T. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- U. Hooks:
  1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
  2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
  3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
  4. Space hooks no more than 5 feet o.c.
  5. Provide a hook at each change in direction.
- V. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- W. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- X. 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.
- Y. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

### **3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS**

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 27 05 44 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

### **3.3 FIRESTOPPING**

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

### **3.4 PROTECTION**

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

**END OF SECTION 27 0528**



**SECTION 27 0544**

**SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING**

**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. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.
- B. Related Requirements:
  - 1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

**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.
- 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.
- C. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized-steel sheet.
  - 2. Minimum Metal Thickness:

- a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## **2.2 SLEEVE-SEAL SYSTEMS**

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

## **2.3 SLEEVE-SEAL FITTINGS**

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

## **2.4 GROUT**

- A. Description: Nonshrink; 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.

## **2.5 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.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

### **PART 3 - EXECUTION**

#### **3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS**

- A. Comply with NECA 1.
- B. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- C. Sleeves for Conduits Penetrating Non-Fire-Rated 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.
- D. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using [steel] [cast-iron] 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.
- F. Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

### **3.2 SLEEVE-SEAL-SYSTEM INSTALLATION**

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### **3.3 SLEEVE-SEAL-FITTING INSTALLATION**

- A. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- B. Using grout, seal the space around outside of sleeve-seal fittings.

**END OF SECTION 27 0544**

**SECTION 27 1500**

**COMMUNICATIONS HORIZONTAL CABLING**

**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. UTP cabling.
  - 2. Cable connecting hardware, patch panels, and cross-connects.
  - 3. Telecommunications outlet/connectors.
  - 4. Cabling system identification products.
- B. Related Requirements:
  - 1. Section 28 05 13 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

**1.3 DEFINITIONS**

- A. BICSI: Building Industry Consulting Service International.
- B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- D. EMI: Electromagnetic interference.
- E. IDC: Insulation displacement connector.
- F. LAN: Local area network.
- G. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- H. RCDD: Registered Communications Distribution Designer.
- I. UTP: Unshielded twisted pair.

#### **1.4 ADMINISTRATIVE REQUIREMENTS**

- A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

#### **1.5 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
  - 2. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

#### **1.6 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

#### **1.7 CLOSEOUT SUBMITTALS**

- A. Maintenance Data: For splices and connectors to include in maintenance manuals.

#### **1.8 MAINTENANCE MATERIAL SUBMITTALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Device Plates: One of each type.

#### **1.9 QUALITY ASSURANCE**

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
  - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.
  - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

#### **1.10 DELIVERY, STORAGE, AND HANDLING**

- A. Test cables upon receipt at Project site.
  1. Test each pair of UTP cable for open and short circuits.

### **PART 2 - PRODUCTS**

#### **2.1 HORIZONTAL CABLING DESCRIPTION**

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.
  1. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
  2. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

#### **2.2 PERFORMANCE REQUIREMENTS**

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  1. Flame-Spread Index: 25 or less.
  2. Smoke-Developed Index: 50 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### **2.3 UTP CABLE**

- A. Description: 100-ohm, four-pair UTP covered with a thermoplastic jacket.
  1. Comply with ICEA S-90-661 for mechanical properties.
  2. Comply with TIA/EIA-568-B.1 for performance specifications.
  3. Comply with TIA/EIA-568-B.2, Category 6.

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4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
  - a. Communications, General Purpose: Type CM or CMG.
  - b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.

## **2.4 UTP CABLE HARDWARE**

- A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- B. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
  1. Number of Jacks per Field: One for each four-pair UTP cable indicated conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- D. Patch Cords: Factory-made, 28-gauge, four-pair cables in 48-inch lengths; terminated with eight-position modular plug at each end.
  1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
  2. Patch cords shall have color-coded boots for circuit identification.

## **2.5 TELECOMMUNICATIONS OUTLET/CONNECTORS**

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
- B. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate.
  1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 26 27 26 "Wiring Devices."
  2. For use with snap-in jacks accommodating any combination of UTP work area cords.
    - a. Flush mounting jacks, positioning the cord at a straight angle.
  3. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

## **2.6 IDENTIFICATION PRODUCTS**

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.



- B. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

## **2.7 SOURCE QUALITY CONTROL**

- A. Factory test UTP cables according to TIA/EIA-568-B.2.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

## **PART 3 - EXECUTION**

### **3.1 WIRING METHODS**

- A. Install cables in pathways except within cabinets and in accessible ceiling spaces. Conceal pathways and cables except in unfinished spaces. All cable in unfinished spaces shall be installed in conduit.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements in Section 27 05 28 "Pathways for Communications Systems."
- B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures:
  - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
  - 2. Install lacing bars and distribution spools.
  - 3. Install conductors parallel with or at right angles to sides and back of enclosure.

### **3.2 INSTALLATION OF CABLES**

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
  - 1. Comply with TIA/EIA-568-B.1.
  - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
  - 3. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
  - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  - 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

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6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
  7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
  8. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
  9. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.2.
  2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.
- D. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
  3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
  3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

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4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

### **3.3 FIRESTOPPING**

- A. Comply with TIA-569-B, Annex A, "Firestopping."
- B. Comply with BICSI TDMM, "Firestopping Systems" Article.

### **3.4 IDENTIFICATION**

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
  1. Administration Class: 2.
  2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Cable and Wire Identification:
  1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
  2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
  3. Exposed Cables: Label each cable at intervals not exceeding 15 feet.
  4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.

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- b. Label each unit and field within distribution racks and frames.
- 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- D. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
  - 1. Cables use flexible vinyl or polyester that flex as cables are bent.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Visually inspect UTP cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
  - 2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
  - 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  - 4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
    - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 5. UTP Performance Tests:
  - a. Test for each outlet. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
    - 1) Wire map.
    - 2) Length (physical vs. electrical, and length requirements).
    - 3) Insertion loss.
    - 4) Near-end crosstalk (NEXT) loss.
    - 5) Power sum near-end crosstalk (PSNEXT) loss.
    - 6) Equal-level far-end crosstalk (ELFEXT).
    - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
    - 8) Return loss.
    - 9) Propagation delay.
    - 10) Delay skew.

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6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
  - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
  - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**END OF SECTION 27 1500**



**SECTION 28 0513**

**CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY**

**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. UTP cabling.
  - 2. RS-232 cabling.
  - 3. RS-485 cabling.
  - 4. Control-voltage cabling.
  - 5. Control-circuit conductors.
  - 6. Fire alarm wire and cable.
  - 7. Identification products.

**1.3 DEFINITIONS**

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

**1.4 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

## **PART 2 - PRODUCTS**

### **2.1 PERFORMANCE REQUIREMENTS**

- A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - 1. Flame-Spread Index: 25 or less.
  - 2. Smoke-Developed Index: 50 or less.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### **2.2 RS-232 CABLE**

- A. Standard Cable: NFPA 70, Type CM.
  - 1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
  - 2. Polypropylene insulation.
  - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
  - 4. PVC jacket.
  - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
  - 6. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
  - 1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
  - 2. PE insulation.
  - 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
  - 4. Fluorinated ethylene propylene jacket.
  - 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
  - 6. Flame Resistance: Comply with NFPA 262.

### **2.3 RS-485 CABLE**

- A. Standard Cable: NFPA 70, Type CM[ or Type CMG].
  - 1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
  - 2. PVC insulation.



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3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262, Flame Test.

## **2.4 CONTROL-VOLTAGE CABLE**

A. Paired Cable: NFPA 70, Type CMG.

1. One pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.
6. All cabling configurations and conductor sizing shall be per the manufacturer's written instructions. This information shall be coordinated and verified prior to release of materials.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.
6. All cabling configurations and conductor sizing shall be per the manufacturer's written instructions. This information shall be coordinated and verified prior to release of materials.

## **2.5 CONTROL-CIRCUIT CONDUCTORS**

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.

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- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.
- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF in pathway, complying with UL 83.

## **2.6 FIRE ALARM WIRE AND CABLE**

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760, and as recommended by system manufacturer.
- B. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG, size as recommended by system manufacturer.
  - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- C. Speaker Circuits: Minimum No.14 AWG.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
  - 1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
  - 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

## **2.7 IDENTIFICATION PRODUCTS**

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION OF HANGERS AND SUPPORTS**

- A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

### **3.2 WIRING METHOD**

- A. Install wiring in metal pathways and wireways, or supported concealed above accessible ceilings, unless otherwise noted or approved.
  - 1. Minimum conduit size shall be 3/4 inch. Control and data-transmission wiring shall not share conduits with other building wiring systems.

- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring on Racks and within Enclosures:
  - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM's "Cabling Termination Practices" chapter. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
  - 2. Install lacing bars and distribution spools.
  - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
  - 4. Install conductors parallel with or at right angles to sides and back of enclosure.
  - 5. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in any enclosure onto terminal blocks.
  - 6. Mark each terminal according to system's wiring diagrams.
  - 7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

### **3.3 INSTALLATION OF CONDUCTORS AND CABLES**

- A. Comply with NECA 1 and NFPA 70.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
- D. Install cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- E. General Requirements for Cabling:
  - 1. Comply with TIA-568-C.1.
  - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
  - 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
  - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  - 5. Maintain minimum cable bending radius during installation and termination of cables.

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6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
9. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.
10. Comply with Section 28 05 44 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 26 05 29 "Hangers and Supports for Electrical Systems."
3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-C recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communication cables in grounded metallic pathways and unshielded power lines or electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic pathways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

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- a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

### **3.4 FIRE ALARM WIRING INSTALLATION**

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal pathway according to Section 28 05 28 "Pathways for Electronic Safety and Security."
- 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Where installed in conduit, fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated pathway system. This system shall not be used for any other wire or cable.
- C. Wiring Method:
- 1. Cables and pathways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
  - 2. Fire-Rated Cables: Use of two-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is not permitted.
  - 3. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or pathway as signaling line circuits.
- D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another for supervisory circuits. Color code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

- G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

### **3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS**

- A. 120-V Power Wiring: Install according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. Minimum Conductor Sizes:
  - 1. Class 1 remote-control and signal circuits, No. 14 AWG.
  - 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
  - 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.
  - 4. Audio speaker circuits, No. 14 AWG.

### **3.6 CONNECTIONS**

- A. Comply with requirements in Section 28 31 11 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

### **3.7 FIRESTOPPING**

- A. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
- B. Comply with TIA-569-C, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

### **3.8 GROUNDING**

- A. For communication wiring, comply with J-STD-607-A and with BICSI TDMM's "Grounding, Bonding, and Electrical Protection" chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Section 28 05 26 "Grounding and Bonding for Electronic Safety and Security."

### **3.9 IDENTIFICATION**

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

### **3.10 FIELD QUALITY CONTROL**

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

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1. Visually inspect UTP and optical-fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
  2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
    - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- B. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

**END OF SECTION 28 0513**





**SECTION 28 0528**

**PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY**

**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. Metal conduits, tubing, and fittings.
  - 2. Metal wireways and auxiliary gutters.
  - 3. Boxes, enclosures, and cabinets.
- B. Related Requirements:
  - 1. Section 26 05 33 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
  - 2. Section 27 05 28 "Pathways for Communications Systems" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving communications systems.

**1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

**PART 2 - PRODUCTS**

**2.1 METAL CONDUITS, TUBING, AND FITTINGS**

- A. Refer to Section 26 05 33 – Raceway and Boxes for Electrical Systems.

**2.2 METAL WIREWAYS AND AUXILIARY GUTTERS**

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

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1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Comply with TIA-569-B.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Wireway Covers: Hinged type unless otherwise indicated.
- D. Finish: Manufacturer's standard enamel finish.

### **2.3 SURFACE PATHWAYS**

- A. Surface Metal Pathways: Galvanized steel with snap-on covers complying with UL 5.

### **2.4 BOXES, ENCLOSURES, AND CABINETS**

- A. Refer to Section 26 05 33 – Raceway and Boxes for Electrical Systems.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-C.
  2. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
  3. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
  4. Gangable boxes are prohibited.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, with continuous-hinge cover with flush latch unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- F. Cabinets:
1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  2. Hinged door in front cover with flush latch and concealed hinge.
  3. Key latch to match panelboards.
  4. Metal barriers to separate wiring of different systems and voltage.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- C. Complete pathway installation before starting conductor installation.
- D. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications wiring conduits for which only two 90-degree bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for pathways.
  - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- K. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- L. Surface Pathways:
  - 1. Install surface pathway for surface electrical outlet boxes only where indicated on Drawings.
  - 2. Install surface pathway with a minimum 2-inch radius control at bend points.

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3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- M. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway sealing fittings according to NFPA 70.
- N. Install devices to seal pathway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
  1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where otherwise required by NFPA 70.
- O. Flexible Conduit Connections: Comply with NEMA RV 3. Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
  1. Use LFMC in damp or wet locations subject to severe physical damage.
  2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- P. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Q. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- R. 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.
- S. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

**3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS**

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling."

**3.3 FIRESTOPPING**

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 84 13 "Penetration Firestopping."

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### **3.4 PROTECTION**

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

**END OF SECTION 28 0528**



**SECTION 28 0544**

**SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY PATHWAYS AND CABLING**

**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. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Sleeve-seal fittings.
  - 4. Grout.
  - 5. Silicone sealants.
- B. Related Requirements:
  - 1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

**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.
- 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.
- C. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized-steel sheet.
  - 2. Minimum Metal Thickness:

- a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## **2.2 SLEEVE-SEAL SYSTEMS**

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

## **2.3 SLEEVE-SEAL FITTINGS**

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

## **2.4 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.

## **2.5 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.
- B. Silicone Foams: Multicomponent, silicone-based, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.



## **PART 3 - EXECUTION**

### **3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS**

- A. Comply with NECA 1.
- B. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed.
  - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
- C. Sleeves for Conduits Penetrating Non-Fire-Rated 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.
- D. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.
- F. Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

### **3.2 SLEEVE-SEAL-SYSTEM INSTALLATION**

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

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- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

**3.3 SLEEVE-SEAL-FITTING INSTALLATION**

- A. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- B. Using grout, seal the space around outside of sleeve-seal fittings.

**END OF SECTION 28 0544**