

PROJECT MANUAL

ESSER HVAC UPGRADES AT THE FOLLOWING SCHOOLS:

JOHNSON ELEMENTARY SCHOOL – RPS#2307

CONKLIN CREEK ELEMENTARY SCHOOL – RPS#2308

AUBURN HIGH SCHOOL – RPS#2309

FROBERG ELEMENTARY SCHOOL – RPS#2310

WEST VIEW ELEMENTARY SCHOOL – RPS#2407

FAIRVIEW EARLY CHILDHOOD SCHOOL – RPS#2410

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 23 - 14 HVAC Upgrades at Six Schools

KED PROJECT NO. 21-129, 21-130, 21-127, 21-128, 21-207, 21-210

Date:

September 9, 2022

	Specification Sections:
	Divisions 00, 01, 02, 03, 05, 06, 07, 08, 09, 22, 23, 26, 27, 28
	Signature:
	Name: Ryan C. Reef
	License Number: 062-056761
Expiration Date: 11-21-2023	
Date: 09-09-2022	



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PROJECT MANUAL

ESSER HVAC UPGRADES AT THE FOLLOWING SCHOOLS:

- (1) JOHNSON ELEMENTARY SCHOOL – RPS#2307
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RPS#2410

501 7TH Street, Rockford, IL 61104

ROCKFORD PUBLIC SCHOOLS 205

FOR

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501 7TH Street, Rockford, IL 61104
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IFB 23-14 HVAC Upgrades at Six Schools

KED PROJECT NO. 21-129. 21-130. 21-127. 21-128. 21-207. & 21-210

DATE: September 9, 2022

Keith Engineering Design, Inc.
707 N.E. Jefferson Ave.
Peoria, Illinois 61603
Illinois Design Firm Registration Number: 184-000000

MEP/FP ENGINEERING



DANIEL G. SAAVEDRA
Licensed Architect
LIC. EXPIRES: 11/30/2022



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

Date

Date

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN
HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY
CHILDHOOD CENTER
ROCKFORD PUBLIC SCHOOLS 205
ROCKFORD, ILLINOIS

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BID OFFER FORM

Bid # 23-13 ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
FOR ROCKFORD PUBLIC SCHOOL DISTRICT 205.

BID SUBMITTED BY: _____

Date _____

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:

COMBINED BASE BID: JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL AND FAIRVIEW EARLY CHILDHOOD CENTER

TOTAL: _____ DOLLARS (\$ _____)

BREAKDOWN OF COMBINATION BID: (ACCOUNTING PURPOSES ONLY)

For Owners internal allocation purposes please show pricing breakdown per school (only as applies to combination bid).

INDIVIDUAL COST: JOHNSON ELEMENTARY SCHOOL

TOTAL: _____ DOLLARS (\$ _____)

INDIVIDUAL COST: CONKLIN ELEMENTARY SCHOOL

TOTAL: _____ DOLLARS (\$ _____)

INDIVIDUAL COST: AUBURN HIGH SCHOOL

TOTAL: _____ DOLLARS (\$ _____)

INDIVIDUAL COST: FROBERG ELEMENTARY SCHOOL

TOTAL: _____ DOLLARS (\$ _____)

INDIVIDUAL COST: WEST VIEW ELEMENTARY SCHOOL

TOTAL: _____ DOLLARS (\$ _____)

INDIVIDUAL COST: FAIRVIEW EARLY CHILDHOOD CENTER

TOTAL: _____ DOLLARS (\$ _____)

BID OFFER FORM

UNIT PRICES:

Should the net result of change for any of the following categories of work require more or less quantity of work than originally indicated in the Drawings and/or Specifications, the price for such added or deducted work will be as follows:

No. _____ Description _____	\$ _____ PER _____
No. _____ Description _____	\$ _____ PER _____
No. _____ Description _____	\$ _____ PER _____

ALLOWANCES:

Under Base Bid, the Contractor shall include a quantity allowance of [Quantity] [units] to [Description of Allowance]. The unit price(s) will be used at the end of the project, to adjust the contract price up or down.

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

BID OFFER FORM

performance and payment bond as well as insurance coverage, as specified in strict accordance with the Contract Documents.

Date of Commencement of Construction: _____

Date of Substantial Completion: _____

Date of Final Completion: _____

BIDDER _____
(Corporation) (Partnership) (Individual) Circle One

Address _____
_____ Street

_____ City _____ State _____ Zip Code

_____ Phone No. _____ Email address

BIDDER FEIN/SSN NO. _____

By: _____
_____ Print name

Title: _____

Subscribed and sworn to before be 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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY
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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

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SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW
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ROCKFORD PUBLIC SCHOOLS 205
ROCKFORD, ILLINOIS

SECTION 01 1000

PART 1 - GENERAL

SUMMARY OF WORK

1.1 GENERAL

- A. The General Conditions, Supplementary Conditions and Division 1 - General Requirements are hereby made a part of each Division and Section of the Specifications.

1.2 DESCRIPTION

- A. Work covers complete construction and installation of work specified and/or required, including all trades for the Rockford PS ESSER HVAC Upgrades for Rockford Public School, Winnebago County, Illinois, hereinafter called the Owner and is to be constructed in accordance with the Contract Documents prepared by Saavedra Group Architects, 504 North Church St. Rockford, Illinois, the Architect.
- B. Products shall be installed in strict accordance with manufacturer recommendations. The Contractor shall review substrates prior to installing products. Installation of products shall represent that the Contractor has accepted the substrates as proper for the installation of products. Substrates which are not acceptable shall be corrected prior to the installation of products.

1.3 CONTRACT

- A. Work to be executed under one General Contract, including all trades.

1.4 COOPERATION BETWEEN CONTRACTORS

- A. The Contractor shall coordinate construction activities with the other Contractors performing projects as required to assure a complete, proper, and timely completion of all of the Work.

1.5 COOPERATION OF CONTRACTOR WITH THE OWNER

- A. Contractors are to conduct the Work and operations so that the usual 7 days per week activities which occur in and around the facility, can continue without interruption, and with as little inconvenience to the Owner as possible.
 - 1. Existing building systems must remain operational to facilitate safe, code compliant occupancy and use of the facility. Minor interruptions of short duration shall not occur without prior notification and approval by the Owner and are to be limited to off days or times when the facility is not occupied.
 - 2. Utilities, fire alarm, and security system shut-offs shall not occur without prior notification and approval by the Owner, and not without contact by the Contractor with the Authority Having Jurisdiction. Shut downs are to be limited to off days or times when the facility is not occupied.
- B. Maintain clear and proper exiting through areas of work. Coordinate requirements with Owner.

1.6 WORK SCHEDULE

- A. The schedule for this work shall be as follows:

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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1. Start the Work immediately after the contract is fully executed.
 2. Begin Work in the Field not later than 06/05/2023.
 3. Substantially Complete all Work not later than: Auburn High School: 08/05/2024
All other Schools: 08/05/2023
- B. Utilities Shut-offs shall not occur without prior notification and approval by the Owner.
- C. The Contractor shall include expedited delivery schedules, additional labor shifts, overtime work, etc. necessary to complete the Work as scheduled.
- D. The only considerations for adjustment of the Substantial Completion Date will be for strikes that shut down the Project, unless such strike was instituted as a result of the conduct of the Contractor; or for delays due to damage caused by Acts of God consisting only of tornadoes or floods in which case the Substantial Completion Date will be extended by the number of days the Project is shut down. Change Orders will be considered part of the Work and will not be a consideration for adjustment of the Substantial Completion Date unless they are specifically requested by the Owner as a Scope of Work Change Order and exceed \$10,000 each, in which case the additional number of days shall be identified and agreed to as part of the Change Order. No other considerations will be allowed.

1.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Product Delivery; Schedule deliveries in accordance with the project schedule, to minimize storage time at project site, and to prevent overcrowding of construction areas and Owner's facilities.
- B. Deliver products to project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
- C. Inspect products on delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.

1.8 PROJECT CONDITIONS

- A. Utilities Shut-offs shall not occur without prior approval of the Owner.
- B. Furniture and Equipment Relocation
1. Owner will move unfixed and unattached furniture and equipment from the work areas prior to the Contractor starting operations. The Contractor shall relocate and reinstall all fixed and attached furniture and equipment, to location(s) as directed by the Owner. Reinstall to proper working condition. Items placed in storage shall be labeled, with all parts and components packaged together. Contractor to patch holes, etc. at original location to match adjacent surfaces and materials.
- C. Criminal background checks shall be performed for the project.
1. The Contractor shall submit a criminal history background check for all persons who will be working in the school building or on school property including those employed directly by the Contractor and those employed by subcontractors and suppliers who will be utilized on the project.
 2. No one will be allowed on-site before the Owner receives and provides the Contractor with the results of the background checks.

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3. Only those employees who have been cleared through their background checks will be allowed on-site. The cost of the background check shall be the responsibility of the Contractor.
- D. Security Plan to Identify Construction Trade Workers
1. Buildings and Grounds Dept. will be consulted on construction project scheduling. Schedules for work within the existing building will be coordinated with the principal taking into consideration building activities.
 2. All workers are required to sign in at the Custodial Office each morning before proceeding to the work area within the existing building. Sign-in sheets will be turned into the Custodial Office each evening.
 3. Clothing that identifies a worker's employer and/or a badge, worn in plain sight, is required at all times while in and around a school building.
 4. It will be the responsibility of the Contractor to notify all construction trades under his contract of the security plan. The Contractor will be responsible for all workers wearing identifying clothing or badges and will be responsible for assessing and collecting fines from the trade contractors.
- E. Cleaning and Dustproofing
1. Rubbish and debris resulting from the Work shall be collected by the Contractor, removed at the end of each day, and legally disposed of away from the site.
 2. Furniture and equipment in the work area shall be covered to prevent dust accumulation and damage.
 3. Surfaces in the work area shall be vacuumed and wiped clean. Books and similar items exposed to dust shall be individually dusted.
- F. Cutting of Masonry Units
1. Cutting of new masonry units shall be done outside of the existing building in an area to prevent dust from entering the existing building. At no time will contractors be allowed to saw cut new masonry within the existing building.
- G. Protection of Existing Surfaces
1. The Contractor shall provide and maintain during the course of construction temporary protection to protect existing surfaces in the existing building from damage due to the construction activities. Such protection will include, but not be limited to temporary barricades to separate work areas from occupied areas to prevent dust and fume penetration, temporary floor covers to protect existing surfaces from damage, etc.
 2. Should damage to existing surfaces occur, the Contractor shall repair at his own expense.
- H. Installation of Materials with Color Variations
1. Materials are subject to color variation during the manufacturing or installation process. For this reason, there may be variations in shade, color or texture.
 2. Contractor shall mix and/or blend these materials to produce a uniform and consistent final appearance to meet the approval of the Architect.

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3. Should there be variation in shade, color or texture which are not acceptable, the Contractor shall repair or replace at his own expense.

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. None

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.
 - 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.

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- 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

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- 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

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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.

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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.

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- 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

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SECTION 01 7320

CUTTING AND PATCHING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The Contractor shall provide connections, repairs, watertight facilities, etc., as required in new construction. Each subcontractor shall furnish information to the Contractor as to size, location, etc., or accept the responsibility of doing the necessary cutting, patching at his own expense.
- B. The Contractor shall provide cutting, fitting or patching for work that may be required to make several parts come together properly, in accordance with the Contract Documents.
- C. Do not endanger the stability of the structure or any part thereof by cutting, digging or otherwise.
- D. The Contractor shall patch and match existing surfaces and materials, etc., affected by the work or patch and match existing surfaces with new materials, etc. as noted.

END OF SECTION 01 7320

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SECTION 01 7700

CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
 - 1. Substantial Completion procedures
 - 2. Final Completion procedures
 - 3. Extended Warranties
 - 4. Record Drawings
 - 5. Record Topographic Survey
 - 6. Operation and Maintenance Manuals
 - 7. Attic stock materials
 - 8. Allowances accounting
 - 9. Final cleaning
 - 10. Repair of the Work

1.2 SUBMITTALS

- A. Submittals Prior to Substantial Completion
 - 1. Letter from the Contractor to the Architect stating the project has achieved Substantial Completion
 - 2. Contractor's List of Items to be Completed or Corrected
 - 3. Specified certifications
- B. Submittals Prior to Final Completion
 - 1. Written notice that the Work is ready for final inspection and acceptance
 - 2. Letter stating that items included in the Architect's (Amended) List of Items to be Completed or Corrected have been completed or otherwise resolved for acceptance
 - 3. Evidence of final, continuing insurance coverage complying with insurance requirements
 - 4. Demonstration and training video recordings
 - 5. Extended Warranties
 - 6. Record Drawings
 - 7. Record Topographic Survey
 - 8. Operation and Maintenance Manuals
 - 9. Attic stock materials

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10. Allowances accounting
11. Waste Management Plan documenting a summary of recycling and salvage on-site logs, manifests, weight tickets, receipts, etc.

1.3 SUBSTANTIAL COMPLETION PROCEDURES

- A. Inspection Procedures: Submit a written request for inspection to determine Substantial Completion a minimum of ten (10) calendar days prior to date the work will be completed and ready for inspection. On receipt of request, Architect will either schedule an inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of critical items that must be completed or corrected before a certificate will be issued.
 1. Reinspection: Request reinspection when the critical items previously identified have been completed or corrected.
 2. On receipt of the reinspection request, Architect will either schedule an inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection has confirmed that the critical items have been completed or corrected.
 3. Substantial Completion is contingent upon the issuance of the Occupancy Permit by the Authority Having Jurisdiction (AHJ), therefore the date of Substantial Completion is subject to change to coincide with the date of Occupancy.
- B. List of Incomplete Items: When the Contractor considers the Work to be Substantially Complete, the Contractor shall prepare and submit a list of items to be completed and corrected (Contractor's punch list).
 1. When the Architect determines the Work is Substantially Complete, the Architect will issue the Amended List of Items to be Completed or Corrected (Architect's punch list) to the Contractor.
- C. Submittals Prior to Substantial Completion: Complete the following a minimum of ten (10) calendar days prior to requesting inspection for determining date of Substantial Completion.
 1. Submit specified certifications through the electronic submittal process. Non-reviewed, non-approved and incomplete documentation is not acceptable.
 2. After the electronic submittals have been accepted for contract compliance, submit three (3) clean, legible, approved copies of the specified certifications to the Architect at least ten (10) calendar days prior to the occupancy walk through by the AHJ. Each set of the approved documentation shall be bound in a three ring binder with tab divisions. Approved documentation binders will be transmitted by the Architect to the AHJ and subsequently delivered to Owner.
 3. Following is the list of specified certifications to be included in each binder.
 - a. Contractor Certification that no asbestos containing materials were used on the Project.
 - b. Environmental Remediation Clearance Documents filed by the Contractor to the AHJ.

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- c. Environmental Testing Report including Indoor Air Quality (IAQ) test results which demonstrate that the factors tested are within permissible exposure limits.
 - d. Roofing System Manufacturer Inspection Report describing deficiencies with the roofing work and items that are to be completed or corrected.
 - e. Plumbing Systems Site: Chlorination test results for water main work indicating satisfactory compliance with Contract Documents transmitted under letterhead of the responsible Trade Contractor.
 - f. Mechanical Systems: Contractor Certification indicating the Heating, Ventilating, and Air Conditioning Systems have been inspected and start up procedures have been completed by the manufacturer and the systems are fully operational including functional temperature controls.
 - g. Boiler Systems: Certification that the boiler system has been inspected and tested by the manufacturer and is fully operational including functional temperature controls. The boiler system shall be inspected and approved by the Office of State Fire Marshal.
 - h. Mechanical Systems Testing and Balancing: Complete test and balance report including Contractor Certification indicating that at a minimum, code compliant fresh air changes are provided.
 - i. Mechanical System Ductwork Tightness Testing Report including test results which demonstrate the required results to pass.
- 4. Other items which are required to achieve Substantial Completion include but are not necessarily limited to the following: completed finishes and suspended ceiling systems; functional door hardware; corridors clear of debris and construction equipment; operational plumbing fixtures; electrical panels properly labeled; and interior signage indicating room numbers, directions, offices, and occupancy loads properly posted in assembly areas. Fire extinguishers, furnished by the Owner, must be installed in each cabinet and wall mounted at locations indicated.
- D. Procedures Prior to Substantial Completion: Complete the following a minimum of ten (10) calendar days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.
 - 1. Advise Owner of pending insurance changeover requirements.
 - 2. Complete startup and testing of systems and equipment.
 - 3. Advise Owner of changeover in heat and other utilities.
 - 4. Participate with Owner in conducting inspection and walkthrough with local emergency responders.
 - 5. Complete final cleaning requirements, including touchup painting.
 - 6. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- E. Procedures Following Substantial Completion: Complete the following items immediately after Substantial Completion.
 - 1. Maintenance of seed, sod, plantings and landscaping areas.

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2. Removal of temporary facilities and protections. Restore modifications to existing facilities to the original design or configuration.
3. Make final changeover of permanent locks and coordinate delivery of keys to Owner. Advise Owner's personnel of changeover in security provisions.
4. Perform preventive maintenance on equipment used prior to Substantial Completion.
5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings.
6. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.

1.4 FINAL COMPLETION PROCEDURES

- A. Preliminary Procedures: Before requesting final inspection for determining Final Completion, complete the following:
 1. Submit letter stating that items included in the Architect's (Amended) List of Items to be Completed or Corrected have been completed or otherwise resolved for acceptance.
 2. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.
 3. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings.
 4. Submit Extended Warranties
 5. Submit Record Drawings
 6. Submit Operation and Maintenance Manuals
 7. Deliver attic stock materials
 8. Submit allowances accounting
- B. Inspection: Submit a written request for final inspection to determine acceptance. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will review the final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
 1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.5 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.
 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
 2. Training recordings must include both high quality video and audio.

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3. Coordinate with Owner for required staff to be in attendance. Include a sign-in sheet to verify attendance.
- B. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.
- C. Video Recording Format: Provide high-quality color video recordings with menu navigation.
- D. Instructor Qualifications: A factory-authorized service representative experienced in operation and maintenance procedures and training.
- E. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

1.6 EXTENDED WARRANTIES

- A. Submit written extended warranties, as defined as warranties beyond the standard one year warranty period from the date of Substantial Completion, via the electronic submittal process.
 1. Warranty shall include the following information:
 - a. Name of the project.
 - b. Name of the warranty provider.
 - c. Description of the item being warranted.
 - d. Effective dates of the warranty, starting with the date of Substantial Completion.
 - e. Terms and conditions in conformance with the specified warranty.
- B. Upon acceptance of the warranties through the submittal process, the Contractor shall collect and assemble hard copy originals of the accepted warranties. Organize extended warranty documents into an orderly sequence based on the table of contents of the Project Manual.
 1. Bind warranties in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
 2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
 3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.
- C. Where applicable, provide additional copies of each warranty to include in operation and maintenance manuals.

1.7 RECORD DRAWINGS

- A. The Contractor and the Site Utilities, Mechanical, Electrical, Plumbing and Fire Protection Trade Contractors shall each maintain during construction a set of record drawings which shall be kept on site. Each set of these drawings shall be labeled in neat large printed letters "RECORD DRAWINGS". Contractors shall record information concurrently with

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construction progress and shall not conceal work until the required information is recorded. Concealed portions of the work which have not been documented shall be opened to fully document conditions at the Contractor's own cost.

- B. Record drawings shall be copies of the Contract Document drawings and shall be clearly and legibly marked to record actual construction, including the following.
 - 1. Changes made by Addenda, Change Directives, and/or Change Orders; clarifications not on Contract Documents drawings.
 - 2. Fully document horizontal and vertical locations of underground site utility and storm sewer lines and appurtenances referenced to permanent surface improvements with depths of various elements in relations to finish floor datum.
 - 3. Fully document horizontal and vertical locations of underground and under-slab service lines (plumbing, fire protection, mechanical, electric) and appurtenances referenced to permanent improvements with depths of various elements in relations to finish floor datum.
 - 4. Location of interior service lines (plumbing, fire protection, mechanical, electric) and devices concealed in above ground construction referenced to visible and accessible features of the structure.
 - 5. Location of concealed equipment, valves, ducts, dampers, access panels, outlets, etc. referenced to visible and accessible features of the structure.
 - 6. Field changes of dimensions and details.
 - 7. Other deviations made from the original Contract Document drawings.
- C. The Contractor shall make available record drawings for review for compliance. The frequency of review shall be at a minimum, 50% gross completion of the Contract and at Substantial Completion. The Contractor shall provide complete sets to facilitate review. If it is determined that the record drawings are not being maintained concurrently with construction progress, subsequent pay applications will not be reviewed until the record drawings are brought up to date.
- D. At the completion of the preparation of the record drawings, each contractor shall clearly indicate on the cover sheet of the drawings, "NAME OF CONTRACTOR" and "DATE" identifying the contractor who prepared the record drawings and the date of the record drawings.
- E. Prior to Final Completion, the Contractor shall deliver an electronically scanned copy of the record drawings in PDF format to the Architect for delivery to the Owner.

1.8 OPERATION AND MAINTENANCE MANUALS

- A. Submit operation and maintenance manuals via the electronic submittal process.
- B. Upon acceptance of the operation and maintenance manuals through the submittal process, the Contractor shall submit a final corrected version of the operation and maintenance manuals via the electronic submittal process and shall also collect and assemble hard copies of the accepted operation and maintenance manuals. Organize operation and maintenance manuals into an orderly sequence based on the table of contents of the Project Manual.
 - 1. Bind operation and maintenance manuals in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.

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2. Where documents do not allow for hole punching (such as under-sized documents or full size drawings), provide plastic sleeve for insertion into the three-ring binder.
 3. Provide heavy paper dividers with plastic-covered tabs for each separate section. Mark tab to identify the section. Provide a typed description of the sections, including the name of the product and the name, address, and telephone number of Installer.
 4. Identify each binder on the front and spine with the typed or printed title "OPERATION AND MAINTENANCE MANUAL", Project name, and name of Contractor.
 5. Provide additional documentation as specified elsewhere.
- C. Where applicable, provide additional copies of each warranty to include in operation and maintenance manuals.
- D. Submit three (3) copies of each operation and maintenance manual binder to the Architect for processing and distribution.

1.9 ATTIC

- A. Submit attic stock to the Owner as required. Coordinate time and location of delivery of attic stock with designated Owner's representative. Prepare a sign-off form for signature by the designated Owner's representative indicating acceptance and quantity of the attic stock items. Failure to obtain the designated Owner's representative sign-off shall represent that the attic stock delivery did not occur. A copy of the fully executed sign-off form shall be submitted to the Architect.

1.10 ALLOWANCE ACCOUNTING

- A. The Contractor shall submit a comprehensive accounting of each specified allowance with appropriate supporting documentation to justify the actual quantities used.
- B. Each allowance accounting item shall include the specified allowance amount and the actual amount of the allowance used and the net difference.
- C. A Change Order(s) will be prepared indicating the corresponding adjustments to the contract amount based upon adjusted allowance amounts.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 3 - EXECUTION

3.1 FINAL CLEANING

- A. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
1. Complete the following cleaning operations before requesting inspection for Certification of Substantial Completion for entire Project or for a designated portion of Project:

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- a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
- b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
- c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
- d. Remove tools, construction equipment, machinery, and surplus material from Project site.
- e. Remove snow and ice to provide safe access to building.
- f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
- g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
- h. Sweep concrete floors broom clean.
- i. Remove protections used to prevent dust accumulation and damage to furniture and equipment in the work area.
- j. Vacuum and wipe clean surface, furniture and equipment in the work area. Books within the work area shall be individually dusted.
- k. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
- l. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
- m. Remove labels, wrapping and protective films that are not permanent.
- n. Wipe surfaces of mechanical and electrical equipment, elevator equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
- o. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
- p. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
- q. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
- r. Leave Project clean and ready for occupancy.

3.2 REPAIR OF THE WORK

- A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.
- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.
 - 1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
 - 2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that already show evidence of repair or restoration.
 - a. Do not paint over "UL" and other required labels including door and frame fire ratings.
 - b. Do not paint over identifications including mechanical and electrical nameplates.
 - c. Remove paint applied to required labels and identification.
 - 3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
 - 4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and HID fixtures to comply with requirements for new fixtures.

3.3 ELECTRONIC CLOSEOUT DOCUMENTATION

- A. General: Provide a complete project closeout documentation package in electronic format. This package shall include:
 - 1. Project Record Drawings
 - 2. Project Manual
 - 3. Approved Submittals
 - 4. Operation and Maintenance Manuals
 - 5. Warranties
 - 6. Owner training DVD's
 - 7. Project Contact Directory including sub-contractors
- B. In order to facilitate the Electronic Closeout Documentation process, comply with the following procedures:
 - 1. Contact Digital Revolution, Inc. a minimum of three months prior to the date of Substantial Completion to schedule a pre-closeout meeting. Review the following:

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- a. Format of documents: PDF electronic format for documents.
 - b. Folder structure for storage and transfer of files.
 - c. Schedule for collection and turn-over of closeout documentation.
 - d. Record Document format procedures: Provide clean and accurate paper copies of the marked-up Record Documents (Drawings and Specifications) for scanning.
 - e. Provide contact information for the individual responsible for the collection and transfer of the electronic closeout Documentation package contents.
 - f. Review a complete listing of closeout documentation package contents.
2. Provide Documentation to Digital Revolution, Inc. for processing no later than 30 days after the date of Substantial Completion.
 3. Schedule a training conference with the Owner's Representative, Architect, Construction Manager and Digital Revolution, Inc. to present the completed Electronic Closeout Documentation Package.

END OF SECTION 01 7700

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- B. In order to facilitate the Electronic Closeout Documentation process, comply with the following procedures:
1. Contact Digital Revolution, Inc. a minimum of three months prior to the date of Substantial Completion to schedule a pre-closeout meeting. Review the following:
 - a. Format of documents: PDF electronic format for documents.
 - b. Folder structure for storage and transfer of files.
 - c. Schedule for collection and turn-over of closeout documentation.
 - d. Record Document format procedures: Provide clean and accurate paper copies of the marked-up Record Documents (Drawings and Specifications) for scanning.
 - e. Provide contact information for the individual responsible for the collection and transfer of the electronic closeout Documentation package contents.
 - f. Review a complete listing of closeout documentation package contents.
 2. Provide Documentation to Digital Revolution, Inc. for processing no later than 30 days after the date of Substantial Completion.
 3. Schedule a training conference with the Owner's Representative, Architect, Construction Manager and Digital Revolution, Inc. to present the completed Electronic Closeout Documentation Package.

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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.

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- 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
 - 4. leak.
 - 5. Water leak.
 - 6. Power failure.
 - 7. Water outage.
 - 8. System, subsystem, or equipment failure.
- 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.

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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.

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- 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.

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- 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.

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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

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SECTION 03 15 00

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

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

END SECTION 03 15 00

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CONCRETE ACCESSORIES

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

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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.

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CAST-IN-PLACE CONCRETE

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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%

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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 6" to 8" 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.

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- 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:

Description	Concrete Finish
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.

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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.

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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

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

END SECTION 03 30 00

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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.

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- 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.
 - 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

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SECTION 04 20 00

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.

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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.

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- 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.
- 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.

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- 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.
- R. Cavity Vents: Molded polyvinyl chloride grilles; insect resistant.
- S. Cleaning Solution: Non-acidic, not harmful to masonry work or adjacent materials.

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- 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:
 - 1. Bond: Running.

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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.
 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.

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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.
 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.

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- 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:
 - 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.

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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.
- 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

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SECTION 05 12 00

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.

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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.

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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.
- 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

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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.

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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.
 - 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

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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.
 - 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

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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

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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

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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

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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.

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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

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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.

3.6 REPAIRS AND PROTECTION

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

END SECTION 05 1200

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SECTION 05 2100

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.

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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

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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

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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,

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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 SECTION 05 2100

SECTION 05 3123

STEEL ROOF DECKING

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel roof 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 SUBMITTALS

- A. Shop Drawings: Indicate deck plan, support locations, projections, openings and reinforcement, pertinent details and accessories, fasteners and fastener pattern diagram.

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- B. Product Data: Submit deck profile characteristics and dimensions, structural properties, and finishes.
- C. Manufacturer's Installation Instructions: Submit manufacturer's installation instructions.
- D. Manufacturer's Certificates: Certify products meet or exceed specified requirements.
- E. Welders Certificates: Certify welders employed on Work verifying AWS qualification within previous twelve months.

1.4 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.

PART 2 – PRODUCTS

A. 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

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- 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 AND RETROFIT OF EXISTING DECK

- 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

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distortion.

- 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 SECTION 05 3123

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SECTION 05 5000

METAL FABRICATIONS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section covers the work necessary for miscellaneous metal work including, but not limited to, the following:
 - 1. Anchor Bolts and Fastenings
 - 2. Miscellaneous Metal Supports
 - 3. Aluminum Grating and Treads
 - 4. Miscellaneous Metal Shapes
 - 5. Aluminum Stairs
 - 6. Aluminum Ladders
- B. The Contractor shall perform all work as indicated below unless otherwise noted, and any additional work to produce a complete, finished job.

1.2 SUBMITTALS

- A. Submittals shall be as specified in the General Conditions.
- B. Submit the following:
 - 1. Certified copies of test reports of factory tests required by the applicable standards.
 - 2. Shop drawings and performance data and physical characteristics for miscellaneous metals fabrication.
 - a. Include details of dimensions, cuts, connections, camber, holes, and other pertinent data. Indicate welds by standard AWS symbols, and show size, length, and type of each weld.
 - b. Provide setting drawings, templates, and directions for the installation of anchor bolts and other anchorages to be installed by others.
 - 3. Welding certification as specified in this Section.

1.3 MATERIALS AND WORKMANSHIP

- A. Metal work shall be finished straight, smooth, and even and free from defects and to the sizes specified and required.
- B. The Contractor shall frame all work. Materials shall be manufactured and delivered in ample time for the installation of work built into structures.

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- C. The Contractor shall provide all necessary angles, brackets, metal inserts, anchor bolts, frames, adjusting screws, and bolt gaskets to properly secure metal work to the masonry, structural steel framing, or other parts of the structure; and all other items necessary for the complete installation of the work intended, whether or not specified herein or shown on the Drawings. Use of rivets are not allowed.
- D. Welding for steel, and in particular anodized aluminum and stainless steel, shall be neat, symmetrical, clean, and unobtrusive in appearance.

1.4 QUALITY ASSURANCE

- A. The Contractor shall design and construct all work in accordance with the Illinois Building Code, latest edition. Design briefs shall be submitted, if required.

- B. Codes and Standards

Comply with the provisions of the followings, except as otherwise indicated:

- 1. AISC "Code of Standard Practice for Steel Buildings and Bridges". Paragraph 4.2.1 of this code is hereby modified by deletion of the following sentence: "This approval constitutes the owner's acceptance of all responsibility for the design adequacy of any connections designed by the fabricator as a part of his preparation of these shop drawings."
- 2. AISC "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings", including "Commentary" and Supplements thereto as issued.
- 3. AISC "Specifications for Structural Joints using ASTM A 325 or A 490 Bolts", approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation.
- 4. American Welding Society (AWS) D1.1 "Structural Welding Code-Steel".
- 5. ASTM A 6 "General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural Use".
- 6. Structural aluminum construction shall conform to the Aluminum Association's Aluminum Design manual "Specifications for Aluminum Structures – Allowable Stress Design".

- C. Qualifications for Welding Work

- 1. Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedure".
- 2. Provide certification that welders to be employed in the work have satisfactorily passed AWS qualification tests. If recertification of welders is required, retesting will be the Contractor's responsibility.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. All metal fabrications shall be prominently marked for identification in assembly either by painting or attached tag.

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- B. Metals shall be handled and stored in such a manner as to prevent damage, corrosion, or deterioration of paint finishes.
- C. All aluminum pipe and elbows shall be packed and shipped in individual plastic film to protect the anodized finish.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Unless specified otherwise, materials shall meet the following requirements:
 - 1. Structural steel and mild steel: ASTM A36
 - 2. Steel pipe: ASTM A-53
 - 3. Steel tubing: ASTM A501
 - 4. Galvanizing 1.25 ounces per square foot of surface area: ASTM A-123
 - 5. Aluminum: Alloy designation of the Aluminum Association

	Description	Alloy Type
a.	Extruded, Structural and rolled Shapes	6061-T6
	Structural Welded Rod	5554
	(Anodized-AA C22 A31)	(5356)
b.	Smooth Plates	5053-T6
	Welded Rod	5356
c.	Tread Plate	6061-T6
	Welding Rod	4043
	(Anodized-AA C22 A31)	(5356)

2.2 STAINLESS STEEL SHAPES, PLATES, AND ANCHOR BOLTS

- A. Stainless steel shapes, plates, and anchor bolts shall conform to the requirements of ASTM A167.
 - 1. Exterior and Submerged Use – A167, Type 316
 - 2. Industrial Uses – A167, Type 316
 - 3. Interior and Architectural Use – A167, Type 302/304
 - 4. Anchor Bolts – A167, Type 316

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2.3 REMOVABLE SAFETY CHAINS AND POSTS

- A. Removable safety chains shall be 3/16" proof coil chain 1/2" x 1-18" c/c, oval shaped, stainless steel links and snap hooks.
- B. Posts shall be 1 1/2" I.P.S. clear anodized to the Aluminum Association Specification AA C22 A31 aluminum pipe of Alloy Type 6063-T6 with 0.145" wall thickness.

2.4 GRATING

- A. Grating shall be clear anodized to Aluminum Association Specification AA C22 A31 aluminum alloy Type 6063-T6, ASTM-6-221. Grating shall be Type 15-SGI-4 unless otherwise shown.
- B. Grating shall consist of straight extruded bearing bars or shapes placed edge-wise, interconnected rigidly by interlocking cross-bridges or spacers and serrated or scored on top to produce a skid resistant surface. Grating shall be designed to support a uniform safe load of not less than 200 pounds per square foot with a maximum deflection of 1/400 of the span, including grating with openings or patchwork.
- C. Where covered grating is indicated in the Drawings, grating shall be covered on the underside with 18 gauge aluminum plate. The aluminum plate shall have the same dimensions as the grating to which it is attached. The plate shall be attached to the grating with stainless steel hold-down clips and 1/4" stainless steel hardware. Clip spacing and placement shall be sufficient to prevent any sag or excessive stress in the aluminum plate. The outer edge of the plate which rests on the grating supports along the edge of the channel and the front edges of the plate which butt against adjoining plates shall have continuous rubber seals attached.
- D. Perforated covered grating shall be the same as covered grating, with 1/4" holes drilled at two inch centers in the aluminum plate to allow for drainage, and the plate shall be installed on the top side of the grating, and screwed permanently to the grating support angles.

2.5 TREAD PLATE

- A. Tread plate covers and frames shall be clear anodized to the Aluminum Association Specification AA C22 A31 aluminum alloy Type 6063-T6. Tread plate cover shall be the 3/64" raised diamond pattern.

2.6 STAIR TREADS AND PLATFORMS

- A. Stair treads and platforms shall be aluminum grating capable of withstanding a uniform load of 100 pounds per square foot or a concentrated load of 300 pounds on an area of four square inches located in the center of the tread or platform, whichever produces the greatest stress.

2.7 SPECIAL GRATING AND TREAD PLATE SUPPORT

- A. Special grating and tread plate supports such as angles, channels, I-beams, and other metal parts shall be clear anodized to Aluminum Association Specification AA C22 A31 aluminum alloy Type 6061-T6.

2.8 ANCHOR BOLTS AND FASTENINGS

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- A. Unless specified otherwise; nuts and bolts, washers, rivets, and screws shall be stainless steel.
- B. Fastening for stainless steel and aluminum work shall be stainless steel.
- C. Stainless steel shall be ASTM A-276, Type 304 standards.
- D. Structural high strength bolts shall be ASTM A-325 standards.
- E. Anchors or fastenings required to fix equipment after concrete has been placed shall be the epoxy adhesive type, or alternative anchorage according to the equipment manufacturer's instructions.
- F. Epoxy Adhesive Anchors Standard:
 - 1. Hilti: HIT-RE 500 V3 with Stainless Steel Rod
 - 2. Simpson Strong Tie: ET-Epoxy Tie Adhesive with Stainless Steel Rod

2.9 MISCELLANEOUS SUPPORTS

- A. Miscellaneous supports, whether or not included in the previous list, shall be clear anodized to Aluminum Association Specification AA C2 A31 aluminum Type 6061-T6.

2.10 ALUMINUM LADDERS

- A. General
 - 1. Fabricate ladders for the locations shown, with dimensions, spacings, details, and anchorages as indicated. Comply with the requirements of ANSI A14.3.
- B. Side Rails
 - 1. Unless shown differently on the Drawings, side rails shall be continuous aluminum channels, C3 x 0.258, with rounded, chamfered, or eased edges, spaced 18 inches apart. Ends of side rails shall have caps or flat bars welded on.
- C. Bar Rungs shall be round bars, $\frac{3}{4}$ " in diameter, spaced at 12 inches on center, unless otherwise indicated.
- D. Fit rungs in centerline of side rails. Plug weld and grind smooth on outer rail faces.
- E. Support each ladder at the top and bottom and at intermediate points spaced not more than five feet on center by means of welded or bolted steel brackets. Size brackets to support design dead and live loads indicated and to hold centerline of ladder rungs clear of the wall surface by not less than seven inches.
- F. Provide slip-resistant surfaces on the top of each rung, either by coating the rung with aluminum oxide granules set in epoxy resin adhesive, or by using a type of manufacturing rung which is filled with aluminum oxide grout.
- G. Ladder rungs shall be designed to withstand a concentrated live load of 250 pounds with a maximum deflection of 1/8 inch.

RPS 2307, 2308, 2309, 2310, 2407, 2410; IFB 23-14

KED 21-129, 21-130, 21-127, 21-128, 21-207, 21-210 05 5000 - 5

METAL FABRICATIONS

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PART 3 – EXECUTION

3.1 INSTALLATION

- A. Erect miscellaneous structural steel items in accordance with AISC Code.
- B. Erect structural aluminum items in accordance with the Aluminum Association Specifications.
- C. All field welding shall be in accordance with AWS D1.1.
- D. Pipe railing shall be set plumb, straight, and true.
- E. Where dissimilar metals are in contact, or when aluminum is in contact with concrete, mortar, masonry, or pressure-treated wood; protect dissimilar surfaces as specified in Section 09 91 00.
- F. Field assembly shall meet the following requirements:
 - 1. Frames shall be accurately assembled to the lines and elevations indicated.
 - 2. The various members forming parts of a complete frame or structure after being assembled shall be aligned and adjusted accurately before being fastened.
- G. Unless otherwise indicated on the Drawings, provide stainless steel hardware in submerged conditions, including expansion bolts, equipment anchors, nuts, bolts, and washers used for mounting piping, equipment, and other submerged items.

3.2 PAINTING

- A. All items not fabricated from aluminum, stainless steel, or galvanized steel shall be thoroughly cleaned and prepared and given one shop coat of an approved primer in accordance with Section 09 91 00, before shipment. Do not shop coat portions of steel work to be built into concrete except for one inch adjacent to the exposed portions. The Contractor shall paint or touch up abrasion marks where shop paint has been removed or chipped during erection or transportation, using the same paint as specified for shop painting.
- B. The Contractor shall paint all aluminum in contact with concrete or steel with two coats of approved bitumen prior to fixing.

3.3 MISCELLANEOUS SUPPORTS

- A. Miscellaneous supports shall be provided to the sizes, details, and locations as shown on the Drawings.

3.4 FASTENERS

- A. The Contractor shall install stainless steel bolts and washers for all aluminum connections.

END SECTION 05 5000

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. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube 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: Carbon steel, with corrosion-resistant coating, 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.

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- 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.

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

END OF SECTION 21 0517

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

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 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 piping and with OD that completely covers opening.

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

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 21 0518

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. Two-piece ball valves with indicators.
 - 2. Bronze butterfly valves with indicators.
 - 3. Iron butterfly valves with indicators.
 - 4. Check valves.
 - 5. Bronze OS&Y gate valves.
 - 6. Iron OS&Y gate valves.
 - 7. NRS gate valves.
 - 8. Indicator posts.
 - 9. Trim and drain valves.

1.3 ACTION SUBMITTALS

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

1.4 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 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.
- D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
 - 1. Main Level: HAMV - Fire Main Equipment.
 - a. Level 1: HCBZ - Indicator Posts, Gate Valve.
 - b. Level 1: HLOT - Valves.
 - 1) Level 3: HLUG - Ball Valves, System Control.
 - 2) Level 3: HLXS - Butterfly Valves.
 - 3) Level 3: HMER - Check Valves.
 - 4) Level 3: HMRZ - Gate Valves.
 - 2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
 - a. Level 1: VQGU - Valves, Trim and Drain.
- B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
 - 1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves.
 - a) Single check valves.
 - 3) Miscellaneous valves.
- C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.
- D. ASME Compliance:
 - 1. ASME B16.1 for flanges on iron valves.
 - 2. ASME B1.20.1 for threads for threaded-end valves.
 - 3. ASME B31.9 for building services piping valves.
- E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- F. NFPA Compliance: Comply with NFPA 24 for valves.
- G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.
- H. Valve Sizes: Same as upstream piping unless otherwise indicated.
- I. Valve Actuator Types:
 - 1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 - 2. Handwheel: For other than quarter-turn trim and drain valves.
 - 3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. NIBCO INC.
 - 2. Victaulic Company.
- B. Description:
 - 1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
 - 2. Minimum Pressure Rating: 175 psig.
 - 3. Body Design: Two piece.
 - 4. Body Material: Forged brass or bronze.
 - 5. Port Size: Full or standard.
 - 6. Seats: PTFE.
 - 7. Stem: Bronze or stainless steel.
 - 8. Ball: Chrome-plated brass.
 - 9. Actuator: Worm gear or traveling nut.
 - 10. Supervisory Switch: Internal or external.
 - 11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
 - 12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Fivalco Inc.
 - 2. Globe Fire Sprinkler Corporation.
 - 3. Milwaukee Valve Company.
- B. Description:
 - 1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
 - 2. Minimum: Pressure rating: 175 psig.
 - 3. Body Material: Bronze.
 - 4. Seat Material: EPDM.
 - 5. Stem Material: Bronze or stainless steel.
 - 6. Disc: Stainless steel with EPDM coating.
 - 7. Actuator: Worm gear or traveling nut.
 - 8. Supervisory Switch: Internal or external.
 - 9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
 - 10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Anvil International, Inc.
 - 2. Fivalco Inc.
 - 3. Globe Fire Sprinkler Corporation.
 - 4. Kennedy Valve; a division of McWane, Inc.

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5. NIBCO INC.
6. Tyco Fire & Building Products LP.
7. Victaulic Company.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer.

2.5 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Anvil International, Inc.
2. Fire Protection Products, Inc.
3. Fivalco Inc.
4. Globe Fire Sprinkler Corporation.
5. Kennedy Valve; a division of McWane, Inc.
6. Matco-Norca.
7. Mueller Co.; Water Products Division.
8. NIBCO INC.
9. Reliable Automatic Sprinkler Co., Inc.
10. Shurjoint Piping Products.
11. Tyco Fire & Building Products LP.
12. United Brass Works, Inc.
13. Venus Fire Protection Ltd.
14. Victaulic Company.
15. Viking Corporation.
16. Watts Water Technologies, Inc.
17. Wilson & Cousins Inc.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.6 BRONZE OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

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1. Milwaukee Valve Company.
2. NIBCO INC.
3. United Brass Works, Inc.
4. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
5. Minimum Pressure Rating: 175 psig.
6. Body and Bonnet Material: Bronze or brass.
7. Wedge: One-piece bronze or brass.
8. Wedge Seat: Bronze.
9. Stem: Bronze or brass.
10. Packing: Non-asbestos PTFE.
11. Supervisory Switch: External.
12. End Connections: Threaded.

2.7 IRON OS&Y GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. American Cast Iron Pipe Company; Waterous Company subsidiary.
 2. Clow Valve Company; a division of McWane, Inc.
 3. Hammond Valve.
 4. Kennedy Valve; a division of McWane, Inc.
 5. Mueller Co.; Water Products Division.
 6. NIBCO INC.
 7. Victaulic Company.
 8. Watts Water Technologies, Inc.
- B. Description:
1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
 2. Minimum Pressure Rating: 175 psig.
 3. Body and Bonnet Material: Cast or ductile iron.
 4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
 5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
 6. Stem: Brass or bronze.
 7. Packing: Non-asbestos PTFE.
 8. Supervisory Switch: External.
 9. End Connections: Flanged, Grooved, or Threaded.

2.8 NRS GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. American Cast Iron Pipe Company; Waterous Company subsidiary.
 2. Clow Valve Company; a division of McWane, Inc.
 3. Kennedy Valve; a division of McWane, Inc.
 4. Mueller Co.; Water Products Division.
 5. NIBCO INC.
 6. Victaulic Company.
- B. Description:
1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).

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2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.

2.9 INDICATOR POSTS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. American Cast Iron Pipe Company; Waterous Company subsidiary.
 2. Clow Valve Company; a division of McWane, Inc.
 3. Kennedy Valve; a division of McWane, Inc.
 4. Mueller Co.; Water Products Division.
 5. NIBCO INC.
- B. Description:
 1. Standard: UL 789 and FM Global standard for indicator posts.
 2. Type: Wall.
 3. Base Barrel Material: Cast or ductile iron.
 4. Extension Barrel: Cast or ductile iron.
 5. Cap: Cast or ductile iron.
 6. Operation: Wrench or Handwheel.

2.10 TRIM AND DRAIN VALVES

- A. Ball Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Conbraco Industries, Inc.; Apollo Valves.
 - b. Fire-End & Croker Corporation.
 - c. Fire Protection Products, Inc.
 - d. Flowserve.
 - e. FNW; Ferguson Enterprises, Inc.
 - f. Jomar International, LTD.
 - g. Kitz Corporation.
 - h. Legend Valve.
 - i. Metso Automation USA Inc.
 - j. Milwaukee Valve Company.
 - k. NIBCO INC.
 - l. Potter Roemer.
 - m. Red-White Valve Corporation.
 - n. Tyco Fire & Building Products LP.
 - o. Victaulic Company.
 - p. Watts Water Technologies, Inc.
 2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Design: Two piece.
 - c. Body Material: Forged brass or bronze.

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- d. Port size: Full or standard.
 - e. Seats: PTFE.
 - f. Stem: Bronze or stainless steel.
 - g. Ball: Chrome-plated brass.
 - h. Actuator: Handlever.
 - i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
 - j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.
- B. Angle Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Fire Protection Products, Inc.
 - b. NIBCO INC.
 - c. United Brass Works, Inc.
 - 2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Material: Brass or bronze.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.
- C. Globe Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. NIBCO INC.
 - b. United Brass Works, Inc.
 - 2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Material: Bronze with integral seat and screw-in bonnet.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc Holder and Nut: Bronze.
 - f. Disc Seat: Nitrile.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

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.

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- 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 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

- A. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- B. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- C. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above the pipe center.
- E. Install valves in position to allow full stem movement.
- F. Install valve tags. Comply with requirements in Section 21 0553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.
- G. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
- H. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 21 0523

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. Exposed-type fire-department connections.
- B. Coordinate final location with the local Fire Department.

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 fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Guardian model 6600 angled storz fitting with cap or comparable product by one of the following:
 - 1. American Fire Hose & Cabinet.
 - 2. Elkhart Brass Mfg. Company, Inc.
 - 3. Fire-End & Croker Corporation.
 - 4. Fire Protection Products, Inc.
 - 5. GMR International Equipment Corporation.
 - 6. Guardian Fire Equipment, Inc.
 - 7. Venus Fire Protection Ltd.
 - 8. Wilson & Cousins Inc.
- B. Standard: UL 405.
- C. Type: Exposed, projecting, for wall mounting.
- D. Pressure Rating: 175 psig minimum.
- E. Body Material: Corrosion-resistant metal.

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- F. Inlets: Storz fitting according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Round, brass, wall type.
- I. Outlet: Back, with pipe threads.
- J. Number of Inlets: One.
- K. Escutcheon Plate Marking: Similar to "AUTO SPKR."
- L. Finish: Rough brass or bronze.
- M. Outlet Size: NPS 6.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.
- B. Examine roughing-in for fire-suppression system to verify actual locations of piping connections before fire-department connection installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-type fire-department connections.
- B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 21 1119

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, fittings, and specialties.
 - 2. Fire-protection valves.
 - 3. Sprinklers.
 - 4. Alarm devices.
 - 5. Pressure gages.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

1.4 SYSTEM DESCRIPTIONS

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

1.5 PERFORMANCE REQUIREMENTS

- A. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Available fire-hydrant flow test records indicate the following conditions:
 - a. Static Pressure at Residual Fire Hydrant R: 57 psig.
 - b. Measured Flow at Flow Fire Hydrant F: 1150 gpm.
 - c. Residual Pressure at Residual Fire Hydrant R: 56 psig.
- C. Sprinkler system design shall be approved by authorities having jurisdiction.
 - 1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
 - 2. Sprinkler Occupancy Hazard Classifications:
 - a. Building Service Areas: Ordinary Hazard, Group 1.

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- b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - c. General Storage Areas: Ordinary Hazard, Group 1.
 - d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - e. Office and Public Areas: Light Hazard.
 - 3. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
 - c. Special Occupancy Hazard: As determined by authorities having jurisdiction.
 - d.
 - 4. Maximum Protection Area per Sprinkler:
 - a. Office Spaces: 225 sq. ft.
 - b. Storage Areas: 130 sq. ft.
 - c. Mechanical Equipment Rooms: 130 sq. ft.
 - d. Electrical Equipment Rooms: 130 sq. ft.
 - e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
 - 5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
 - a. Light-Hazard Occupancies: 100 gpm for 30 minutes.
 - b. Ordinary-Hazard Occupancies: 250 gpm for 60 to 90 minutes.
- D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

1.6 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Domestic water piping.
 - 2. Compressed air piping.
 - 3. HVAC hydronic piping.
 - 4. Items penetrating finished ceiling include the following:
 - a. Lighting fixtures.
- E. Qualification Data: For qualified Installer and professional engineer.
- F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- G. Welding certificates.

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- H. Fire-hydrant flow test report.
- I. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- J. Field quality-control reports.
- K. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."

1.8 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.9 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. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

- A. Standard Weight, Galvanized-and Black-Steel Pipe: ASTM A 53/A 53M. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.
- C. Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
- E. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- F. Malleable- or Ductile-Iron Unions: UL 860.
- G. Cast-Iron Flanges: ASME 16.1, Class 125.
- H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
- I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
- J. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Corcoran Piping System Co.
 - c. National Fittings, Inc.
 - d. Shurjoint Piping Products.
 - e. Tyco Fire & Building Products LP.
 - f. Victaulic Company.
 - 2. Pressure Rating: 175 psig minimum.
 - 3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
 - 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
- B. Metal, Pipe-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.

2.4 LISTED FIRE-PROTECTION VALVES

- A. General Requirements:
 - 1. Valves shall be UL listed or FM approved.
 - 2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
 - 3. Minimum Pressure Rating for High-Pressure Piping: 250 psig.
- B. Ball Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Victaulic Company.
 - 2. Standard: UL 1091 except with ball instead of disc.
 - 3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
 - 4. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
 - 5. Valves NPS 3: Ductile-iron body with grooved ends.
 - 6.
 - 7.
- C. Bronze Butterfly Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fivalco Inc.
 - b. Global Safety Products, Inc.
 - c. Milwaukee Valve Company.
 - 2. Standard: UL 1091.
 - 3. Pressure Rating: 175 psig.
 - 4. Body Material: Bronze.
 - 5. End Connections: Threaded.
 - 6.
- D. Iron Butterfly Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- a. Anvil International, Inc.
 - b. Fivalco Inc.
 - c. Global Safety Products, Inc.
 - d. Kennedy Valve; a division of McWane, Inc.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Pratt, Henry Company.
 - h. Shurjoint Piping Products.
 - i. Tyco Fire & Building Products LP.
 - j. Victaulic Company.
 2. Standard: UL 1091.
 3. Pressure Rating: 175 psig.
 4. Body Material: Cast or ductile iron.
 5. Style: Lug or wafer.
 6. End Connections: Grooved.
- E. Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFAC Inc.
 - b. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - c. Anvil International, Inc.
 - d. Clow Valve Company; a division of McWane, Inc.
 - e. Crane Co.; Crane Valve Group; Crane Valves.
 - f. Crane Co.; Crane Valve Group; Jenkins Valves.
 - g. Crane Co.; Crane Valve Group; Stockham Division.
 - h. Fire-End & Croker Corporation.
 - i. Fire Protection Products, Inc.
 - j. Fivalco Inc.
 - k. Globe Fire Sprinkler Corporation.
 - l. Groeniger & Company.
 - m. Kennedy Valve; a division of McWane, Inc.
 - n. Matco-Norca.
 - o. Metraflex, Inc.
 - p. Milwaukee Valve Company.
 - q. Mueller Co.; Water Products Division.
 - r. NIBCO INC.
 - s. Potter Roemer.
 - t. Reliable Automatic Sprinkler Co., Inc.
 - u. Shurjoint Piping Products.
 - v. Tyco Fire & Building Products LP.
 - w. United Brass Works, Inc.
 - x. Venus Fire Protection Ltd.
 - y. Victaulic Company.
 - z. Viking Corporation.
 - aa. Watts Water Technologies, Inc.
 - bb.
 2. Standard: UL 312.
 3. Pressure Rating: 250 psig minimum.
 4. Type: Swing check.
 5. Body Material: Cast iron.
 6. End Connections: Flanged or grooved.

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F. Bronze OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. United Brass Works, Inc.
2. Standard: UL 262.
3. Pressure Rating: 175 psig.
4. Body Material: Bronze.
5. End Connections: Threaded.

G. Iron OS&Y Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - b. American Valve, Inc.
 - c. Clow Valve Company; a division of McWane, Inc.
 - d. Crane Co.; Crane Valve Group; Crane Valves.
 - e. Crane Co.; Crane Valve Group; Jenkins Valves.
 - f. Crane Co.; Crane Valve Group; Stockham Division.
 - g. Hammond Valve.
 - h. Milwaukee Valve Company.
 - i. Mueller Co.; Water Products Division.
 - j. NIBCO INC.
 - k. Shurjoint Piping Products.
 - l. Tyco Fire & Building Products LP.
 - m. United Brass Works, Inc.
 - n. Watts Water Technologies, Inc.
2. Standard: UL 262.
3. Pressure Rating: 250 psig minimum.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.

H. Indicating-Type Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Fivalco Inc.
 - c. Global Safety Products, Inc.
 - d. Kennedy Valve; a division of McWane, Inc.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Shurjoint Piping Products.
 - h. Tyco Fire & Building Products LP.
 - i. Victaulic Company.
2. Standard: UL 1091.
3. Pressure Rating: 175 psig minimum.
4. Valves NPS 2 and Smaller:
 - a. Valve Type: Ball or butterfly.
 - b. Body Material: Bronze.

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- c. End Connections: Threaded.
 - 5. Valves NPS 2-1/2 and Larger:
 - a. Valve Type: Butterfly.
 - b. Body Material: Cast or ductile iron.
 - c. End Connections: Flanged, grooved, or wafer.
 - 6. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch indicating device.
- I. NRS Gate Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - b. American Valve, Inc.
 - c. Clow Valve Company; a division of McWane, Inc.
 - d. Crane Co.; Crane Valve Group; Stockham Division.
 - e. Kennedy Valve; a division of McWane, Inc.
 - f. Mueller Co.; Water Products Division.
 - g. NIBCO INC.
 - h. Tyco Fire & Building Products LP.
 - 2. Standard: UL 262.
 - 3. Pressure Rating: 250 psig minimum.
 - 4. Body Material: Cast iron with indicator post flange.
 - 5. Stem: Nonrising.
 - 6. End Connections: Flanged or grooved.
- J. Indicator Posts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - b. American Valve, Inc.
 - c. Clow Valve Company; a division of McWane, Inc.
 - d. Crane Co.; Crane Valve Group; Stockham Division.
 - e. Kennedy Valve; a division of McWane, Inc.
 - f. Mueller Co.; Water Products Division.
 - g. NIBCO INC.
 - h. Tyco Fire & Building Products LP.
 - 2. Standard: UL 789.
 - 3. Type: Horizontal for wall mounting.
 - 4. Body Material: Cast iron with extension rod and locking device.
 - 5. Operation: Wrench.

2.5 TRIM AND DRAIN VALVES

- A. General Requirements:
 - 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 2. Pressure Rating: 175 psig minimum.
- B. Ball Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Affiliated Distributors.

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- b. Anvil International, Inc.
- c. Barnett.
- d. Conbraco Industries, Inc.; Apollo Valves.
- e. Fire-End & Croker Corporation.
- f. Fire Protection Products, Inc.
- g. Flowserve.
- h. FNW.
- i. Jomar International, Ltd.
- j. Kennedy Valve; a division of McWane, Inc.
- k. Kitz Corporation.
- l. Legend Valve.
- m. Metso Automation USA Inc.
- n. Milwaukee Valve Company.
- o. NIBCO INC.
- p. Potter Roemer.
- q. Red-White Valve Corporation.
- r. Southern Manufacturing Group.
- s. Stewart, M. A. and Sons Ltd.
- t. Tyco Fire & Building Products LP.
- u. Victaulic Company.
- v. Watts Water Technologies, Inc.

C. Globe Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire Protection Products, Inc.
 - b. United Brass Works, Inc.
 - c.
 - d.

D. Plug Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Southern Manufacturing Group.

2.6 SPECIALTY VALVES

A. General Requirements:

- 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
- 2. Pressure Rating:
 - a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
 - b. High-Pressure Piping Specialty Valves: 250 psig minimum.
- 3. Body Material: Cast or ductile iron.
- 4. Size: Same as connected piping.
- 5. End Connections: Flanged or grooved.

B. Alarm Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFAC Inc.
 - b. Globe Fire Sprinkler Corporation.

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- c. Reliable Automatic Sprinkler Co., Inc.
 - d. Tyco Fire & Building Products LP.
 - e. Venus Fire Protection Ltd.
 - f. Victaulic Company.
 - g. Viking Corporation.
 - 2. Standard: UL 193.
 - 3. Design: For horizontal or vertical installation.
 - 4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
 - 5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
 - 6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
- C. Automatic (Ball Drip) Drain Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFAC Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - 2. Standard: UL 1726.
 - 3. Pressure Rating: 175 psig minimum.
 - 4. Type: Automatic draining, ball check.
 - 5. Size: NPS 3/4.
 - 6. End Connections: Threaded.

2.7 SPRINKLER SPECIALTY PIPE FITTINGS

- A. Flow Detection and Test Assemblies:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - 2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 3. Pressure Rating: 175 psig minimum.
 - 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 - 5. Size: Same as connected piping.
 - 6. Inlet and Outlet: Threaded.
- B. Sprinkler Inspector's Test Fittings:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Triple R Specialty.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Viking Corporation.
 - 2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 3. Pressure Rating: 175 psig minimum.

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4. Body Material: Cast- or ductile-iron housing with sight glass.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.
- C. Adjustable Drop Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CECA, LLC.
 - b. Corcoran Piping System Co.
 - c. Merit Manufacturing; a division of Anvil International, Inc.
 2. Standard: UL 1474.
 3. Pressure Rating: 250 psig minimum.
 4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
 5. Size: Same as connected piping.
 6. Length: Adjustable.
 7. Inlet and Outlet: Threaded.

2.8 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFAC Inc.
 2. Globe Fire Sprinkler Corporation.
 3. Reliable Automatic Sprinkler Co., Inc.
 4. Tyco Fire & Building Products LP.
 5. Venus Fire Protection Ltd.
 6. Victaulic Company.
 7. Viking Corporation.
- B. General Requirements:
1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
- C. Automatic Sprinklers with Heat-Responsive Element:
1. Early-Suppression, Fast-Response Applications: UL 1767.
 2. Nonresidential Applications: UL 199.
 3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- D. Sprinkler Finishes:
1. Chrome plated.
 2. Bronze.
 3. Painted.
- E. Special Coatings:
1. Wax.
 2. Lead.
 3. Corrosion-resistant paint.

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- F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- G. Sprinkler Guards:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - 2. Standard: UL 199.
 - 3. Type: Wire cage with fastening device for attaching to sprinkler.

2.9 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Water-Motor-Operated Alarm:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - 2. Standard: UL 753.
 - 3. Type: Mechanically operated, with Pelton wheel.
 - 4. Alarm Gong: Cast aluminum with red-enamel factory finish.
 - 5. Size: 10-inch diameter.
 - 6. Components: Shaft length, bearings, and sleeve to suit wall construction.
 - 7. Inlet: NPS 3/4.
 - 8. Outlet: NPS 1 drain connection.
- C. Electrically Operated Alarm Bell:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell company.
 - b. Notifier; a Honeywell company.
 - c. Potter Electric Signal Company.
 - 2. Standard: UL 464.
 - 3. Type: Vibrating, metal alarm bell.
 - 4. Size: 10-inch diameter.
 - 5. Finish: Red-enamel factory finish, suitable for outdoor use.
- D. Water-Flow Indicators:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ADT Security Services, Inc.
 - b. McDonnell & Miller; ITT Industries.

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- c. Potter Electric Signal Company.
 - d. System Sensor; a Honeywell company.
 - e. Viking Corporation.
 - f. Watts Industries (Canada) Inc.
 2. Standard: UL 346.
 3. Water-Flow Detector: Electrically supervised.
 4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
 5. Type: Paddle operated.
 6. Pressure Rating: 250 psig.
 7. Design Installation: Horizontal or vertical.
- E. Pressure Switches:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFAC Inc.
 - b. Barksdale, Inc.
 - c. Detroit Switch, Inc.
 - d. Potter Electric Signal Company.
 - e. System Sensor; a Honeywell company.
 - f. Tyco Fire & Building Products LP.
 - g. United Electric Controls Co.
 - h. Viking Corporation.
 2. Standard: UL 346.
 3. Type: Electrically supervised water-flow switch with retard feature.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design Operation: Rising pressure signals water flow.
- F. Valve Supervisory Switches:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell company.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. Potter Electric Signal Company.
 - d. System Sensor; a Honeywell company.
 2. Standard: UL 346.
 3. Type: Electrically supervised.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design: Signals that controlled valve is in other than fully open position.
- G. Indicator-Post Supervisory Switches:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Potter Electric Signal Company.
 - b. System Sensor; a Honeywell company.
 2. Standard: UL 346.
 3. Type: Electrically supervised.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design: Signals that controlled indicator-post valve is in other than fully open position.

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2.10 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AMETEK; U.S. Gauge Division.
 - 2. Ashcroft, Inc.
 - 3. Brecco Corporation.
 - 4. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 250 psig minimum.
- E. Water System Piping Gage: Include "WATER" on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building.
- B. Install shutoff valve, pressure gage, drain, and other accessories indicated at connection to water-service piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

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- C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- J. Install alarm devices in piping systems.
- K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- M. Fill sprinkler system piping with water.
- 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.

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. 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.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- K. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

- A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and with NFPA 13 supports.

3.6 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Specialty Valves:
 - 1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.

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2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.7 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

3.8 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 4. Energize circuits to electrical equipment and devices.
 5. Coordinate with fire-alarm tests. Operate as required.
 6. Coordinate with fire-pump tests. Operate as required.
 7. Verify that equipment hose threads are same as local fire-department equipment.
- C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

3.11 DEMONSTRATION

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

3.12 PIPING SCHEDULE

- A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be the following:
 - 1. Schedule 10, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.13 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Pendent, dry sprinklers.
 - 5. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

END OF SECTION 21 1313

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.

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- 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

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.

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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

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.
 - 2. Ernst Flow Industries.
 - 3. Marsh Bellofram.

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4. Miljoco Corporation.
 5. Nanmac Corporation.
 6. Noshok.
 7. Palmer Wahl Instrumentation Group.
 8. REOTEMP Instrument Corporation.
 9. Tel-Tru Manufacturing Company.
 10. Trerice, 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. Trerice, 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.

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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. Terice, 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.

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6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
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.

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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:

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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 0523.14

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.

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- 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.

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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

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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.

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- 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.

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- 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 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.

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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.

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- 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.

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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.

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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.

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

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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.
- 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

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:
 - 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.

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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 inches high.

2.3 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: 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.

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- 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

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.

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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.

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- 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:

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- 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.

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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.
 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.

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- 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.

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- 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.

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- 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:

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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.

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- 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.

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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.

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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

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.

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- 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.

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- 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.

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- 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.

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- 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," "Brazed 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.

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- 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.

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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

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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.

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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 ¾.
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.

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3.2 ADJUSTING

- A. Set field-adjustable flow set points of balancing valves.

END OF SECTION 22 1119

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.

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- 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.

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- 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:

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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.

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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.

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- 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.

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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

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SECTION 221413

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.

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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.

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- 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:

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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.

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- 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 221413

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SECTION 23 0130.52

EXISTING HVAC AIR DISTRIBUTION SYSTEM CLEANING

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 cleaning existing HVAC air-distribution equipment, ducts, plenums, and system components.

1.3 DEFINITIONS

- A. ACAC: American Council for Accredited Certification.
- B. AIHA-LAP: American Industrial Hygiene Association Lab Accreditation Program
- C. ASCS: Air systems cleaning specialist.
- D. CESB: Council of Engineering and Scientific Specialty Boards.
- E. CMI: Certified Microbial Investigator.
- F. CMC: Certified Microbial Consultant.
- G. CMR: Certified Microbial Remediator.
- H. CMRS: Certified Microbial Remediation Supervisor.
- I. EMLAP: Environmental Microbiology Laboratory Accreditation Program.
- J. IEP: Indoor Environmental Professional.
- K. IICRC: Institute of Inspection, Cleaning, and Restoration Certification.
- L. NADCA: National Air Duct Cleaners Association.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Cleaning agents

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1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For an ASCS.
 - 2. For an IEP.
 - 3. For a CMR and a CMRS.
- B. Field Quality-Control Reports:
 - 1. Project's existing conditions.
 - 2. Evaluations and recommendations, including cleanliness verification.
 - 3. Strategies and procedures plan.

1.6 CLOSEOUT SUBMITTALS

- A. Post-Project report.

1.7 QUALITY ASSURANCE

- A. IEP Qualifications: CMI who is certified by ACAC and accredited by CESB.
- B. CMR Qualifications: Certified by ACAC and accredited by CESB.
- C. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.
- D. Cleaning Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to HVAC air-distribution system cleaning, including, but not limited to, review of the cleaning strategies and procedures plan.

PART 2 - PRODUCTS

2.1 HVAC CLEANING AGENTS

- A. Description:
 - 1. Formulated for each specific soiled coil condition that needs remedy.
 - 2. Will not corrode or tarnish aluminum, copper, or other metals.

PART 3 - EXECUTION

3.1 CLEANING

- A. Comply with NADCA ACR, including items identified as "recommended," "advised," and "suggested."
- B. Perform electrical lockout and tagout according to Owner's standards or authorities having jurisdiction.
- C. Remove non-adhered substances and deposits from within the HVAC system.
- D. Complete cleaning in accordance with Owner-Contractor agreed-upon scope of work.
- E. Systems and Components to Be Cleaned:
 - 1. Ductwork (All existing ductwork to be re-used with new HVAC systems):
 - a. Supply-air ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
 - b. Return-air ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
 - c. Exhaust-air ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
 - d. Transfer ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
 - e. Outside-air ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
 - f. Mixed-air ducts, including turning vanes, damper, backdraft dampers, and equipment connections.
- F. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
- G. Particulate Collection:
 - 1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
 - 2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,
- H. Control odors and mist vapors during the cleaning and restoration process.
- I. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

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- J. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
- K. Clean all air-distribution devices, registers, grilles, and diffusers.
- L. Clean non-adhered substance deposits according to NADCA ACR and the following:
 - 1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
 - 2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
 - 3. Clean evaporator coils, reheat coils, and other airstream components.
- M. Air-Distribution Systems:
 - 1. Create service openings in the HVAC system as necessary to accommodate cleaning.
 - 2. Mechanically clean air-distribution systems specified to remove all visible contaminants, so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
- N. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
- O. Mechanical Cleaning Methodology:
 - 1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.
 - a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
 - b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials, such as duct and plenum liners.
 - 2. Cleaning Mineral-Fiber Insulation Components:
 - a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR.
 - b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
 - c. Fibrous materials that become wet shall be discarded and replaced.

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3.2 RESTORATION

- A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR, "Restoration and Repair of Mechanical Systems" Section.
- B. Restore service openings capable of future reopening. Comply with requirements in Section 233113 "Metal Ducts."
- C. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Section 233113 "Metal Ducts"
- D. Replace damaged insulation according to Section 230713 "Duct Insulation."
- E. Ensure that closures do not hinder or alter airflow.
- F. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
- G. Restore manual volume dampers and air-directional mechanical devices inside the system to their marked position on completion of cleaning.
- H. Measure air flows through air-distribution system.
- I. Measure static-pressure differential across each coil.

END OF SECTION 23 0130.52

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SECTION 23 0516

EXPANSION FITTINGS AND LOOPS 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. Flexible-hose packless expansion joints.
 - 2. Alignment guides and anchors.
 - 3. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

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1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

- A. Flexible-Hose Packless Expansion Joints FHEJ-01:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex Pression Ltd.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. Mason Industries, Inc.
 - e. Metraflex
 - 2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 - 3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 - 4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - 5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

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- a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
- 6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
- 7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides AG-01:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advanced Thermal Systems, Inc.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. Flex-Weld, Inc.
 - e. Hyspan Precision Products, Inc.
 - f. Mason Industries, Inc.
 - g. Metraflex Company (The).
- 2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

- 1. Steel Shapes and Plates: ASTM A 36/A 36M.
- 2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
- 3. Washers: ASTM F 844, steel, plain, flat washers.
- 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.

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5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

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2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
1. Anchor Attachment to Steel Structural Members: Attach by welding.
 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 23 0516

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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.

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PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Plastic/Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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.

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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.

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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.
- 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.

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- 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.
- 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.

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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:
 - 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.

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- 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

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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.

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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.

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- d. Nibco.
- 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.

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- 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

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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:

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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 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.

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2. Description:

- a. Standard: MSS SP-67, Type I.
- b. CWP Rating: 150 psig.
- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
- e. Seat: EPDM.
- f. Stem: One- or two-piece stainless steel.
- g. Disc: Aluminum bronze.

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.

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- 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

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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.

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- 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 B31.1 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.

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2. Description:

- a. Standard: MSS SP-80, Type 1.
- 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.

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- b. CWP Rating: 300 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

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.

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- h. Gasket: Asbestos free.

2.5 IRON, GROOVED-END SWING CHECK VALVES

A. Iron, Grooved-End Swing Check Valves, 300 CWP:

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.

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- 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 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.

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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.
 - 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

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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.
- B. Related Requirements:
 - 1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
 - 2. Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" for duct hangers and 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.

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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.

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2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

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.

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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.

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.

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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:
 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.

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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.

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- 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.
- 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.

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- 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.
 - 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.

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- 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.

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- 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.

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- 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.
- 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.

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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.
 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-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

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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.
- 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.

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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

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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:

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- a. Brady Corporation.
 - 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.

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- 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.
 - 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.

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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.

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- 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. Dual-Temperature Piping: White letters on a safety-green background.
 - 4. Low Pressure Steam Piping: White letters on a safety-green background.
 - 5. 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.

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2. Yellow: For hot-air supply ducts.
 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
- 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. Dual-Temperature: 1-1/2 inches, round.
 - d. 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

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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.

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- D. TAB: Testing, adjusting, and balancing.
- 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."

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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.
- 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 TAB SPECIALISTS

- A. Subject to compliance with requirements, available TAB specialists that may be engaged include the following:
 - 1. Balancing Precision Inc.
 - 2. Illinois Certified LLC
 - 3. Riverplace Technologies LLC

3.2 EXAMINATION

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

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1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine 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.

3.3 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:

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1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning 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.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for 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."

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- 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.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. 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.
- 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."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. 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.

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- 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.
- 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.

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3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. 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:

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- 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.
 - 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.

3.8 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.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design gpm.

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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.
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.

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F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the 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.
- 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.

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- 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.
 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.

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- 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.
 - 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:

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- 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.

3.11 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.
 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.

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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.

3.12 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.

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3.13 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.14 PROCEDURES FOR 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.

3.15 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.16 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.

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3.17 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.

3.18 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.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

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3.19 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.
 - d. Face and bypass damper settings at coils.

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- 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.

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- g. Cooling-coil static-pressure differential in inches wg.
- 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:

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- a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and 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:

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- a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- 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.

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- e. Model number and serial number.
- f. Water flow rate in gpm.
- g. Water pressure differential in feet of head or psig.
- h. Required net positive suction head in feet of head or psig.
- i. Pump rpm.
- j. Impeller diameter in inches.
- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. 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

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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. Outdoor, concealed supply and return.
 - 8. Outdoor, exposed supply and return.
 - 9. Indoor, concealed mixed-air ductwork
 - 10. 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.

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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.

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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.

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- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- 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.

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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 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.

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6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 6.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 1. Width: 2 inches.
 2. Thickness: 6 mils.
 3. Adhesion: 64 ounces force/inch in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 1. Width: 2 inches.
 2. Thickness: 3.7 mils.
 3. Adhesion: 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.

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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.

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2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, 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.

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- 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

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

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

3.6 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

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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.
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:

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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:
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, round, combustion-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 3.0-lb/cu. ft. nominal density.
- N. Exposed, round, combustion-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 3.0-lb/cu. ft. nominal density.
- O. 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.
- P. Exposed, rectangular, mixed-air duct insulation shall be one of the following:

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1. Mineral-Fiber Blanket: 2 inches thick providing minimum insulation factor of R-6 after installation and 0.75-lb/cu. ft. nominal density.

3.10 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

1. All exterior ductwork to be non-metal ductwork. See specification 23 3116 – Non-metal Ducts for requirements.

END OF SECTION 23 0713

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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. Dual-service heating and cooling pumps.
 - 2. Dual-service air separator.
 - 3. Dual-service side-stream filters.
 - 4. Chilled-water pumps.
 - 5. Chilled-water air separator.
 - 6. Chilled-water side-stream filters.
 - 7. Chilled-water remote evaporator.
 - 8. Hot-water pumps.
 - 9. Hot-water air separator.
 - 10. Hot-water side-stream filters
 - 11. Steam-to-hot water shell and tube heat exchanger
- 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.

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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.

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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.
- 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.

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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.

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- 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.
 - 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.

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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. Plate & Frame Heat-exchanger (water-to-water or DX-to-water for cooling service) insulation shall be one of the following:
 1. Flexible Elastomeric: 1 inch thick.
- D. Shell & Tube Heat-exchanger (steam-to-water for heating service) insulation shall be one of the following:
 1. Mineral-Fiber, Wrap, Type 1: 4 inch thick .

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- E. Chilled-water pump insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- F. Dual-service heating and cooling pump insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- G. Hot-water pump insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- H. Chilled-water air-separator insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- I. Dual-service heating and cooling air-separator insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- J. Hot-water air-separator insulation shall be one of the following:
 - 1. Mineral-Fiber, Wrap, Type 1: 2 inches thick.
- K. Chilled-water Side-Stream filter-housing insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- L. Dual-service heating and cooling Side-Stream filter-housing insulation shall be one of the following:
 - 1. Flexible Elastomeric: 1 inch thick.
- M. Hot-water Side-Stream filter-housing insulation shall be one of the following:
 - 1. Mineral-Fiber, Wrap, Type 1: 2 inches thick.

END OF SECTION 23 0716

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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. Dual-service heating and cooling piping, indoors.
 - 6. Low-pressure steam 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.

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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.

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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.

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- b. Johns Manville; a Berkshire Hathaway company.
- c. Knauf Insulation.

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.

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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.

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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.
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.

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- a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- D. Metal Jacket:
 - 1. 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.

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3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
 2. Thickness: 6 mils.
 3. Adhesion: 64 ounces force/inch in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
 2. Thickness: 3.7 mils.
 3. Adhesion: 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.

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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.

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- 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.

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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.
 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."

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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

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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 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:

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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.
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.

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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.
- 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:

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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. 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 Liquid, Suction and Hot-Gas Piping:
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inch thick.
- E. Refrigerant Thermostatic Expansion Valves:
 1. Flexible Elastomeric: 1 inch thick.
- F. Dual-Service Heating and Cooling, 40 to 200 Deg F:
 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.

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G. Low Pressure Stream Supply and Low Pressure Return, 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.

H. 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.

I. Pumped Steam Condensate, 200 Deg G and below.

1. All piping sizes: 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. Chilled Water:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 2 inches thick. Provide outdoor field applied jacket see below.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick. Provide outdoor field applied jacket see below.

B. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1 inches thick. Provide outdoor field applied jacket see below.

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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: 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. 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.
 - 1. 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. UV Protected 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.

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- 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.
- 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,

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- 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.
- 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

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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

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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 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.
 - 2. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
 - 3. 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.
 - 4. Raceways:

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- 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.
5. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.
 6. 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.

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- 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.
- 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, IEE 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.

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- 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.
- 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.

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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, 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.
 - 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.

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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".

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.

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- f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
- 7. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
- 8. DDC system network riser diagram indicating the following:
 - a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
 - 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:

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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.

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- 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:

- 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.

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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.

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- 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.

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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.
 - 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:

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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:
 - 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:

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- 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:
 - 1. Current:
 - a. Milliampere: Nearest 1/100th of a milliamperere.
 - 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.

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- 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.
 - 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.

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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.
 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.

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- 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.
 - 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.

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- 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.
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:

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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.
 - c. Servers.
 - d. Gateways.
 - e. DDC controllers, except application-specific controllers.

Q. Continuity of Operation after Electric Power Interruption:

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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:

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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.
 2. Able to communicate with any DDC system controller that is directly connected or connected to DDC system.
- G. Mobile Device:

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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.

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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.
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:

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- 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.
 - n. View limits.
 - o. Enable and disable demand limiting.

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- 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.

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- a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
- 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

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- 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.
- 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.

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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.
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.

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- 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 acknowledgment.
- 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:

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- 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.
 - 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.

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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.

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.

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- 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.
 - 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.

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- 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. Cooling 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.
- 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.

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- 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.

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.

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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:

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:

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- 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.
 - 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.

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- 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:

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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:
 - 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:

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- 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:

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:

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- 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.
 - 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.

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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:

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.

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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:
 - 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.

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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.
- 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.

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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.
 - 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.

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- 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.
 - 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.

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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.
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).

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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:
 - a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
 - b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

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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.
 - b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

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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.

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2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
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.

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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.
 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:

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- 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.
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.

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- 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.
 - 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.

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- 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:
 - 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:

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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.

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.

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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.
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.

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- 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.
 - 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.

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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."
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.

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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."
 - 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."

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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."
 - 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.

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- 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.
- 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.

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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:
 - 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

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- 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.
- 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.

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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.
 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.

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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".
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.

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- 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.

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.

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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.
- 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.

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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.
- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

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- 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.

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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.
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.

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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.
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.

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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.
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.

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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 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.

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- 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.
- 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.

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- 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:

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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.

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.

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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:

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.

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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.
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.

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- 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

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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.

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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, 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.

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- 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.
- 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.

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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.
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:

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- 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:
 - 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.

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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:
 - 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.

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- 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.
- 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.

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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.

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:

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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:

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.

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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

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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.

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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.

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- 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.
 - 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

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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

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- 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. 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.

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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.

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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.

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- c. Seals:
 - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - 2) Jambs: Stainless steel, compression type.
- 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.

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- 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.
 - 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.

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- 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.
 - 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.

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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:

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- 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.
 - 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.

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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.
- 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.

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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.
 - 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.

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- 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."
- 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."

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- 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.

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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

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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.

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- D. PTFE: Polytetrafluoroethylene.
- 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.

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- 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.

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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.
 - 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:

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- 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:
 - 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.

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- 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.
 - 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:

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- 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.
 - 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.

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- 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.
 - 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.

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- 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.
 - 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.

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- 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.
 - 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.

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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.
 - 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.

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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.
 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.

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- 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).
- 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.

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- 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:
 - 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:

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- 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:
 - 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:

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- 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:
- 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.

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- 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).
- G. Vortex Shedding Flow Meter with Integral Temperature Measurement:
- 1. Description:
 - a. Flow measurement using vortex shedder body with integral 1000-ohm platinum RTD.
 - b. Meter NPS 3/8 through NPS 8.
 - c. Each meter shall be factory calibrated at five points from zero to 250 fps and tagged accordingly against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for meter.
 - d. Each meter shall be programmed using project-specific application data.
 - e. Meter shall include integral diagnostics to verify installation conditions and proper operation.
 - 2. Performance:
 - a. Volumetric Flow Accuracy: Within 1 percent of reading for meter NPS 1 and larger; within 2 percent of reading for smaller sizes.
 - b. Mass Flow Accuracy: Within 1.5 percent of reading for NPS 1 and larger; within 2.5 percent of reading for smaller sizes.
 - c. Ambient Temperature: Zero to 132 deg F.
 - d. Process Temperature: 25 to 464 deg F.
 - e. Pressure: Equal to flange rating.
 - 3. Output Signals:
 - a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 1000-ohm load.
 - b. Digital Signal: Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.
 - 4. Operator Interface:
 - a. Keypad.
 - b. Digital Display: Two-line digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, and temperature and support field programming of all parameters.
 - 5. Construction:

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- a. Material: Type 316L stainless steel for sizes through NPS 4; Type 304 stainless steel for larger sizes.
 - b. Connection: Class 300 flange.
 - c. Vortex Shedder: Unalloyed titanium.
 - d. Shedder Seal: Nickel-plated Inconel.
 - e. Enclosure:
 - 1) Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) NEMA 250, Type 4X.
 - 4) Electrical Connection: Screw terminals.
 - 5) Conduit Connection: Two, 1/2-inch trade size.
6. Remote Display Module:
- a. Remote from meter.
 - b. House in a NEMA 250, Type 4 enclosure.
 - c. Label terminal strip for all wiring connections.
 - d. 120-V ac power supply with 24-V dc output to power the flow meter.
 - e. Input Signal from Meter: Analog current, 4 to 20 mA.
 - f. Output Signals:
 - 1) Analog Current Output: Two wire, 4 to 20 mA, maximum loop resistance 275 ohms.
 - 2) Digital Output (Isolated): Solid-state dry contacts rated for 100 mA at 50-V dc.
 - g. Digital Display:
 - 1) Flow rate.
 - 2) Totalized flow.
 - 3) Display Digits: 3.5 for flow rate and 8 for totalization.
 - h. Local reset of flow totalization.
 - i. Program and data shall be stored in nonvolatile memory in the event of power loss.
7. Upstream Flow Straightener:
- a. Flow straightener where required by installation.
 - b. Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
 - c. Straightener size shall match meter size.
- H. Vortex Shedding Flow Meter with Integral Pressure and Temperature Measurement:
- 1. Description:
 - a. Mass flow measurement corrected for density using vortex shedder body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.

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- b. Meter NPS 1/2 through NPS 12.
 - c. Each meter shall be factory calibrated at five points from Zero to 250 fps and tagged accordingly against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for meter.
 - d. Each meter shall be programmed using project-specific application data.
 - e. Meter shall include integral diagnostics to verify installation conditions and proper operation.
- 2. Performance:
 - a. Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.
 - b. Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.
 - c. Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.
 - d. Repeatability: Within 0.1 percent.
 - e. Long-Term Stability: Within 0.1 percent per year.
 - f. Ambient Temperature: Minus 40 to plus 185 deg F.
 - g. Process Temperature: Minus 40 to plus 464 deg F.
 - h. Pressure: Equal to flange rating.
- 3. Output Signals:
 - a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 1000-ohm load.
 - b. Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gage pressure and temperature.
 - c. Digital Signal:
 - 1) Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30-V dc.
 - 2) HART, FSK protocol.
- 4. Operator Interface:
 - a. Keypad.
 - b. Digital Display: Two-line digital display of alphanumeric characters. The meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.
- 5. Construction:
 - a. Material: Type 316L stainless steel.
 - b. Connection: Class 150 flange.
 - c. Enclosure:

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- 1) Epoxy-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) NEMA 250, Type 6.
 - 4) Electrical Connection: Screw terminals.
 - 5) Conduit Connection: Two, 1/2-inch trade size.
6. Upstream Flow Straightener:
 - a. Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer's installation recommendations.
 - b. Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.
 - c. Straightener size shall match meter size.
- I. Vortex Shedding Flow Meter for Hazardous Environments:
 1. Standard: ASME MFC-6M.
 2. Description:
 - a. FM Approved for hazardous environments.
 - 1) Intrinsically safe for Class I, Division 1, Groups A, B, C, and D; Class II and III, Division 1, Groups E, F, and G.
 - 2) Explosion-Proof for Class I, Division 1, Groups B, C, and D.
 - 3) Dust-Ignition-Proof for Class II and III, Division 1, Groups E, F, and G.
 - b. Sensor shall be isolated from process and replaceable without breaking process seals.
 - c. Meter immune to vibration.
 - d. Clog-free design eliminates gaskets and ports.
 - e. Meter NPS 1/2 through NPS 12.
 - f. Each meter shall be factory calibrated and provided with a certificate of calibration.
 - g. Meter shall be furnished with a permanently attached stainless-steel tag.
 - h. Meter shall include integral diagnostics to verify proper operation.
 3. Performance:
 - a. Flow Accuracy: Within 0.65 percent of reading plus 0.025 percent of span for Reynolds numbers 20000 and larger.
 - b. Repeatability: Within 0.1 percent of flow rate.
 - c. Long-Term Stability: Within 0.1 percent of flow rate per year.
 - d. Response Time: Greater of three vortex shedding cycles or 0.2 seconds.
 - e. Dampening: Adjustable between 0.2 to 255 seconds.
 - f. Ambient Temperature: Minus 58 to plus 250 deg F.
 - g. Humidity: Zero to 95 percent noncondensing.
 - h. Process Temperature: Minus 40 to plus 450 deg F.
 - i. Pressure: Equal to flange rating.
 4. Output Signals:

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- a. Analog Current Signal of Flow Rate:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 1000-ohm load.
- b. Digital Signal:
 - 1) Pulse output for flow totalization.
 - 2) HART protocol.
- 5. Digital Display: Digital display of alphanumerical characters. The meter shall display flow rate, flow totalization, percent of range, and current output.
- 6. Body and Flanges:
 - a. Material: Type 316L stainless steel.
 - b. Connection: ASME B16.5, Class 150 flange.
 - c. Enclosure:
 - 1) Polyurethane-painted cast aluminum.
 - 2) Removable screw-on cover.
 - 3) NEMA 250, Type 4X.
 - 4) Electrical Connection: Screw terminals.
 - 5) Conduit Connection: 1/2-inch trade size.

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:

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- a. Discharge Coefficient Factor: Within 0.75 percent of flow rate.
- b. Repeatability: Within 0.1 percent.
- 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:

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- 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.
- 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.

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3. Wetted Parts Construction:
 - a. Bellows: Tin-bronze.
 - b. Vanes: Stainless steel.
 - c. Body: Forged brass.
 - d. Process Connection: NPS 1.
 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.

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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.
 - 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.

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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.
 - 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:

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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.
- 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.

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- 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:

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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.

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.

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- 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.

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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.
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.

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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.
- 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

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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:

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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 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:

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- 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.
- 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.

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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.
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.

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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.
 - 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.

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- 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 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.

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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.

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.

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- 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.
 - 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.

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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.

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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.

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.

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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.
 - 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.

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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.

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.

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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.
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.

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- 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.

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.

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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

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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.

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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 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

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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.
- 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.

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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.
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.

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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.

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:

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- 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 discrete communicating sensor to combine temperature, humidity, and CO2 sensing in blank-face enclosure.

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:

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- 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.
 - 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:

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- 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.
 - 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.

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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
- 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:

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- 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.

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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.

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- 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.
 - 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:

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- 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.
 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.

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- 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:
 - 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.

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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.
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.

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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.
 - 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.

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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.
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.
- 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.

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- 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

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SECTION 23 0993.11.307

SEQUENCE OF OPERATIONS FOR HVAC DDC (JOHNSON ELEMENTARY 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.

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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.
 - a.

1.5 UNIT VENTILATOR CONTROL SEQUENCES

- A. Classroom Unit Ventilators 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 classroom unit 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 fan speed, temperature, and humidity. Unit controller shall be capable of monitoring/controlling temperature, humidity, and C02.

1.6 AIR SUPPLY UNIT (ASU-1)

- A. Air Supply Units 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 ASU 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 and humidity control utilizing for the purpose of dehumidification. Unit controls shall be capable of monitoring/controlling Temperature, humidity and C02.
- B. Temperature control contractor shall establish initial occupied and unoccupied schedules of operation for each ASU and provide programming adjustments to ASU sequence of operation to allow for discharge air reset and static pressure reset.

1.7 VAV TERMINAL UNITS WITH HOT WATER REHEAT CONTROL SEQUENCE

- 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.

1.8 CABINET UNIT HEATERS & UNIT HEATERS

- A. All cabinet unit heaters are constant volume unit with 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.

1.9 FINNED TUBE RADIATION

- A. Provide DDC controls to modulate two-way control valve to maintain space temperature.

1.10 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.
 - a. Occupied Mode: Exhaust fan shall run continuously during occupied mode:
 - b. Unoccupied Mode: Exhaust fan shall be commanded off.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11.307

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SECTION 23 0993.11.308

SEQUENCE OF OPERATIONS FOR HVAC DDC (CONKLIN ELEMENTARY 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.

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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.
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1.5 UNIT VENTILATOR CONTROL SEQUENCES

- A. Classroom Unit Ventilators 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 classroom unit 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 fan speed, temperature, and humidity. Unit controller shall be capable of monitoring/controlling temperature, humidity, and C02.

1.6 AIR SUPPLY UNIT (ASU-1)

- A. Air Supply Units 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 ASU 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 and humidity control utilizing for the purpose of dehumidification. Unit controls shall be capable of monitoring/controlling Temperature, humidity and C02.
- B. Temperature control contractor shall establish initial occupied and unoccupied schedules of operation for each ASU and provide programming adjustments to ASU sequence of operation to allow for discharge air reset and static pressure reset.

1.7 VAV TERMINAL UNITS WITH HOT WATER REHEAT CONTROL SEQUENCE

- 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:
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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.

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- A. All cabinet unit heaters are constant volume unit with heating coil. On a call for heat the supply fan shall sequence on and operate continuously.
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- C. When space temperature is satisfied the supply fan shall shut off.

1.9 FINNED TUBE RADIATION

- A. Provide DDC controls to modulate two-way control valve to maintain space temperature.

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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.
 - a. Occupied Mode: Exhaust fan shall run continuously during occupied mode:
 - b. Unoccupied Mode: Exhaust fan shall be commanded off.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11.308

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SECTION 23 0993.11.309

SEQUENCE OF OPERATIONS FOR HVAC DDC (AUBURN 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.

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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 CHILLED WATER SYSTEM PRIMARY/SECONDARY PUMPING

- A. Chilled Water System Description – The chilled water system is a nominal 450 ton system comprised of two (2) 240 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 two (2) secondary chilled water pumps.
- 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

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3. Individual Chiller Graphic(s) to include all data listed on the supplementary Chiller System Point List, including:
 - a. Chiller Name
 - 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 and CH-2 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

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- 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 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

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- b. Primary CHWP-2 Start/Stop
 - c. Secondary CHWP-3 Start/Stop
 - d. Secondary CHWP-4 Start/Stop
 - e. CH-1 Start/Stop
 - f. CH-2 Start/Stop
- 2. Digital Inputs
 - a. Primary CHWP-1 Status/Alarm
 - b. Primary CHWP-2 Status/Alarm
 - c. Secondary CHWP-3 Status/Alarm
 - d. Secondary CHWP-4 Status/Alarm
 - e. CH-1 Status/Alarm
 - f. CH-2 Status/Alarm
- 3. Analog Inputs
 - a. Primary CHWP-1 Speed Feedback HZ
 - b. Primary CHWP-2 Speed Feedback HZ
 - c. Secondary CHWP-3 Speed Feedback HZ
 - d. Secondary CHWP-4 Speed Feedback HZ
 - e. CH-1 Evaporator Entering Temperature
 - f. CH-1 Evaporator Leaving Temperature
 - g. CH-2 Evaporator Entering Temperature
 - h. CH-2 Evaporator Leaving Temperature
 - i. Chilled Water Supply Temperature
 - j. Chilled Water Return Temperature
 - k. Differential Pressure Sensor 1
 - l. Differential Pressure Sensor 2
 - m. Make-up Water Meter
 - n. CHWP-1 Flow Meter
 - o. CHWP-2 Flow Meter
 - p. De-coupler Flow Meter
 - q. Secondary CHW Flow Meter
- 4. Analog Outputs
 - a. Secondary CHWP-3 Speed Control
 - b. Secondary CHWP-4 Speed Control

1.6 ROOF TOP AIR-HANDLING UNIT RTU-1 (CAFETERIA)

A. RTU-1 Control Sequence:

1. Roof-top Unit, RTU-1 is a semi-custom outdoor single zone variable volume air-handling 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.

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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. 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.

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

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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.

- 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. Optimal Start Mode

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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.

C. 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.

D. 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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E. Safeties and Alarms

1. When mixed air temperature drops below 35 deg F the 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 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 heat from the heating source

F. RTU-1 DDC Control Point List

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G. The Digital Inputs and Outputs listed below are for RTU-1.

1. Digital Outputs

- a. Supply Fan SF-1 Start/Stop
- b. Return/Exhaust Fan REF-1 Start/Stop
- c. Discharge Air Isolation Damper
- d. Hot Water Recirculating Pump Start/Stop

2. Digital Inputs

- a. Supply Fan SF-1 Status/Alarm
- b. Hot Water Recirculating Pump Status
- c. Return/Exhaust Fan REF-1 Status/Alarm
- d. Low Limit Device @ entering face of pre-heat coil
- e. High Limit Positive Static Pressure @ unit discharge
- f. High Limit Negative Static Pressure @ unit return/exhaust intake.
- g. Supply Duct Smoke Detector
- h. Return/Exhaust Duct Smoke Detector
- i. Return/Exhaust Air Filter Differential Pressure Switch
- j. 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-1 Speed (Hz)
- k. Return/Exhaust Fan REF-1 Speed (Hz)
- l. Energy Wheel Rotation
- m. Building Pressure Sensors
- n. Static Pressure Sensors

4. Analog Outputs

- a. Supply Fan VFD
- b. Return/Exhaust Fan VFD
- c. Outdoor Air Damper
- d. Return Air Damper
- e. Wheel Bypass Damper (Exhaust Air)
- f. Wheel Bypass Damper (Outdoor Air)
- g. Pre-heat Coil Control Valve
- h. Chilled Water Control Valve
- i. Energy Wheel VFD

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- j. Outdoor Air Flow Station
- k. Return Air Flow Station

1.7 ROOF TOP UNIT RTU-2

- A. Roof Top Units RTU-2 is a packaged DX cooling, Hot water heat variable-air volume unit. RTU-2 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.
- A. Safeties and Alarms
 - 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.

1.8 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.

1.9 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.

1.10 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

1.11 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.
 - a. Occupied Mode: Exhaust fan shall run continuously during occupied mode:

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- 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 0993.11.309

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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SECTION 23 0993.11.50

SEQUENCE OF OPERATIONS FOR HVAC DDC (FROBERG ELEMENTARY 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 EXISTING - HEATING HOT WATER SYSTEM PRIMARY/SECONDARY PUMPING

- A. Heating Water System Description – The existing heating water system is comprised of two (2) 1,500 MBH Bryan boilers. The boilers have the capability to operate simultaneously in parallel to provide a total nominal heating capacity of 3,000 MBH. The system is designed as primary-secondary pumping system with each boiler provided with a dedicated primary pump. The design is intended to provide constant flow through the each operating boiler utilizing the primary pumps while allowing variable flow to occur through the secondary loop utilizing a separate pair of secondary heating hot water pumps.

1.6 UNIT VENTILATOR CONTROL SEQUENCES

- A. Unit Ventilator Controls: Space temperature sensor with set point adjustment (which can be limited by the district maintenance staff to +/- desired degrees from set point), Space CoO2 sensor [the space temperature and CO2 sensor should be in one housing as a combined unit], discharge air temperature sensor, low limit safety, heating water control valve, DX staging, 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.
 4. Room temperature sensor modulates heating valve and stages DX cooling as required to maintain space set point. When outside air is determined to be acceptable for cooling DX will be locked out of operation and 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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)
 - b. Supply Fan Relay (Low Speed)
 - c. Supply Fan Relay (Medium Speed)
 - d. Supply Fan Relay (High Speed)
 - e. DX Cooling (single stages)
 2. Digital Inputs
 - a. Supply Fan Status
 - b. Low Limit
 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. Outdoor/Return Air Dampers
 - b. Heating Control Valve
 - c. Face and Bypass Dampers

1.7 MINI-SPLIT SYSTEM AC-21/ACCU-21

- A. Furnish and install a DDC temperature sensor to monitor office room temperature and control new mini-split system and associated hot water convector.
1. Cooling mode: Mini-split system shall cycle on/off to maintain set-point temperature of 72 deg F.
 2. Heating mode: Mini-split system shall operate in fan-only mode. Hot water convector control valve shall modulate to maintain room set-point temperature at 72 deg F.
 3. Control sequence shall be programmed to prevent simultaneous heating and cooling. When the mini-split outdoor unit is operating the hot water convector shall be off.

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1.8 EXHAUST FANS (EF-1 & EF-2):

- A. Exhaust fans are constant volume roof / wall 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.
 - a. Occupied Mode: Exhaust fan shall run continuously during occupied mode.
 - b. Unoccupied Mode: Exhaust fan shall be commanded off.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11.310

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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SECTION 23 0993.11.407

SEQUENCE OF OPERATIONS FOR HVAC DDC (WEST VIEW ELEMENTARY 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 AIR HANDLING UNIT W/ SPLIT DX CONDENSING UNIT (AHU-1 / ACCU-1, RF-1)

- A. Air handling unit AHU-1 is a variable volume system with supply fan, remote duct mounted return fan RF-1, outside air damper (normally closed), duct mounted relief air damper (normally closed) and return air damper (normally open) mixing dampers, hot water preheat coil and DX cooling coil. The air handling unit supplies medium pressure air to VAV boxes with duct mounted reheat coils serving the adjacent classrooms and corridors.
- 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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 sensors located in the classrooms and corridors 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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- 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-1 DDC Control Point List

1. Digital Outputs

- a. Supply Fan Start/Stop
- b. Return Fan RF-1 Start/Stop
- c. Hot Water Recirculating Pump Start/Stop
- d. Condensing Unit (Stage 1)
- e. Condensing Unit (Stage 2)
- f. Condensing Unit (Stage 3)
- g. Condensing Unit (Stage 4)

2. Digital Inputs

- a. Supply Fan Status/Alarm
- b. Return Fan RF-1 Status
- c. Hot Water Recirculating Pump Status
- d. Low Limit Device
- e. Pre Filter Differential Pressure Switch
- f. Supply Air Duct Smoke Detector Status
- g. Return Air Duct Smoke Detector Status
- h. Final Filter Differential Pressure Switch
- i. Low Limit Static Pressure Switch
- j. High Limit Static Pressure Switch

3. Analog Inputs

- a. Supply Fan VFD Feedback (Hz)
- b. Return Fan RF-1 VFD Feedback (Hz)
- c. AHU Discharge Supply Air Temperature
- d. Preheat Coil Discharge Air Temperature
- e. Return Air Temperature
- f. Return Air Humidity
- g. Mixed Air Temperature
- h. Outdoor Air Temperature (may be global)
- i. Outdoor Air Humidity (may be global)
- j. Supply Air Static Pressure
- k. Supply Fan Speed (Hz)
- l. Return Fan Speed (Hz)

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4. Analog Outputs

- a. Supply Fan VFD Control
- b. Return Fan RF-1 VFD Control
- c. Preheat Coil Hot Water Control Valve
- d. Cooling Coil Chilled Water Control Valve
- e. Return Air Damper
- f. Outdoor Air Damper
- g. Relief Air Damper

1.6 VAV TERMINAL UNITS WITH HOT WATER REHEAT (TYPICAL ALL)

- A. The VAV terminal units shall be controlled by DDC controllers with electronic volume damper actuators and 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.
 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.

1.7 NEW UNIT VENTILATOR CONTROL SEQUENCES (TYPICAL ALL)

- 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

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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.
4. Room temperature sensor modulates heating hot water and stages DX cooling 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)
 - b. Supply Fan Start-Stop (On/Off)
 - c. Supply Fan Relay (Low Speed)
 - d. Supply Fan Relay (Medium Speed)
 - e. Supply Fan Relay (High Speed)
 - f. DX Cooling (single stages)
 - g.
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

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4. Analog Outputs
 - a. Outdoor/Return Air Dampers
 - b. Heating Control Valve
 - c. Face and Bypass Dampers

1.8 GENERAL EXHAUST FANS (EF-24, EF-34, EF-44, EF-51):

- A. Exhaust fans are constant volume roof mounted / base 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.
 - 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.

1.9 EXHAUST FAN (EF-29):

- A. Exhaust fan is a variable volume inline centrifugal fan. The fans shall be controlled through the BAS as follows:
 1. Exhaust Fan Control:
 - a. Building pressure control: The exhaust fan controller shall sense the building static pressure and shall control the exhaust fan VFD to maintain building static pressure at 0.02 - 0.05" w.g. to outside air. A Static pressure transmitter shall sense building static pressure at one location within the east-wing corridor. The Temperature Control Subcontractor shall trend the static pressure readings for a period of 30 days and submit the trend for review and approval by the engineer.
 - b. Each exhaust fan identified above shall operate based on an occupied/unoccupied schedule provided by BAS. Provide start/stop and status control points.
 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.

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PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11.407

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SECTION 23 0993.11.50

SEQUENCE OF OPERATIONS FOR HVAC DDC (FROBERG ELEMENTARY 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.

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2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 HEATING HOT WATER SYSTEM (Steam To Hot Water Heat Exchanger)

- A. Heating Water System Description – The existing steam heating system is comprised of two (2) existing 2,092 input MBH steam boilers. The boilers have the capability to operate simultaneously in parallel to provide a combined output capacity of 3,450 LBS/Hr of 10 PSI steam. New steam branch piping will be piped to from the existing steam header over to a new shell and tube steam to hot water heat exchanger where hot water will be generated and then pumped throughout the building. A set of hot water pumps (primary / backup) operate allowing variable flow to occur through the hot water loop to all equipment on the hot water system.
- B. The existing steam boiler system is controlled by an existing wall mounted boiler control panel located in the boiler room. The steam boiler plant shall operate as originally designed as it will continue to serve other parts of the building. The new heating steam to hot water controls shall be integrated with the existing steam boiler plant.

A. HEATING HOT WATER PUMP CONTROL

1. The Secondary Heating Hot water pumps HWP-1 and HWP-2 shall be sequenced utilizing a load based lead/lag sequence. The intent is for the lag pump to be 100% standby.
 - a. The lead hot water pump shall be controlled to maintain the design pressure set-point by utilizing differential pressure sensor to control the pump VFD.
 - b. If the lead hot water pump is unable to maintain the desired set-point the BAS shall command on the second hot water pump.
 - c. The BAS shall initiate the shutdown of the next system hot water pump whenever excess pump capacity exists as determined by the pump speed, the system pressure, and the number of pumps running.
 - d. Hot water pump HWP-1 shall be controlled in the same fashion as hot water pump HWP-2.

B. HEATING HOT WATER SYSTEM DDC CONTROL POINT LIST

1. Digital Outputs

- a. Pump HWP-1 Start/Stop
- b. Pump HWP-2 Start/Stop

2. Digital Inputs

- a. Pump HWP-1 Status/Alarm

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b. Pump HWP-2 Status/Alarm

3. Analog Inputs

- a. Steam Supply Temperature
- b. Steam Supply Pressure
- c. Steam 1/3 Control Valve – Position
- d. Steam 2/3 Control Valve – Position
- e. Hot Water Supply Temperature
- f. Hot Water Return Temperature
- g. Hot Water Differential Pressure
- h. HWP-1 Speed (Hz)
- i. HWP-2 Speed (Hz)
- j. Make-up Water Meter
- k. HX-1 Flow Meter

4. Analog Outputs

- a. HWP-1 VFD Output
- b. HWP-2 VFD Output
- c. Steam 1/3 Control Valve
- d. Steam 2/3 Control Valve

1.6 UNIT VENTILATOR CONTROL SEQUENCES

- A. Unit Ventilator Controls: Space temperature sensor with set point adjustment (which can be limited by the district maintenance staff to +/- desired degrees from set point), Space CoO2 sensor [the space temperature and CO2 sensor should be in one housing as a combined unit], discharge air temperature sensor, low limit safety, heating water control valve, DX staging, 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 valve and stages DX cooling as required to maintain space set point. When outside air is determined to be acceptable for cooling DX will be locked out of operation and 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)
 - b. Supply Fan Relay (Low Speed)
 - c. Supply Fan Relay (Medium Speed)
 - d. Supply Fan Relay (High Speed)
 - e. DX Cooling (single stages)
2. Digital Inputs
 - a. Supply Fan Status
 - b. Low Limit
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. Outdoor/Return Air Dampers
 - b. Heating Control Valve
 - c. Face and Bypass Dampers

1.7 EXHAUST FANS (EF-1, EF-2, & EF-3):

- A. Exhaust fans are constant volume roof / wall mounted centrifugal fans. The fans shall be controlled through the BAS as follows:

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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.
 - a. Occupied Mode: Exhaust fan shall run continuously during occupied mode.
 - b. Unoccupied Mode: Exhaust fan shall be commanded off.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11.410

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SECTION 23 1123

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: **100 psig** minimum unless otherwise indicated.
 - 2. Service Regulators: **100 psig** minimum unless otherwise indicated.
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.5 psig or less.

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1.5 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Dielectric fittings.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- C. Qualification Data: For qualified professional engineer.
- D. Welding certificates.
- E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For **pressure regulators** to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

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

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1.9 DELIVERY, STORAGE, AND HANDLING

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

1.10 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.11 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

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2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

2.2 PIPING SPECIALTIES

- A. Y-Pattern Strainers:
 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: **40**-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 4. CWP Rating: 125 psig.
- B. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

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1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
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. A.Y. McDonald Mfg. Co.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. BrassCraft Manufacturing Co.; a Masco company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Bronze Plug Valves: MSS SP-78.
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:

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- a. A.Y. McDonald Mfg. Co.
 - b. Lee Brass Company.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

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

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. American Meter Company.
 - b. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
 - c. Maxitrol Company.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.

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11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

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. Eaton.
 - b. Maxitrol Company.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 5 psig.

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. 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. A.Y. McDonald Mfg. Co.
 - b. Wilkins.
 - c. Zurn Industries, LLC.
2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

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PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

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

3.3 INDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.

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- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 3. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.

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- S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.

3.5 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.

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3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.7 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

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- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.9 PAINTING

- A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.
- B. Finished Areas exposed to view: Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior latex matching topcoat.
 - c. Topcoat: Interior latex (low sheen).
 - d. Color: match existing.
- C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

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

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3.11 DEMONSTRATION

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

3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

- A. Aboveground, branch piping NPS 1 and smaller shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 2 PSIG

- A. Aboveground, branch piping NPS 1 and smaller shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with steel welding fittings and welded joints.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES 2 PSIG AND HIGHER

- A. Aboveground Piping: Maximum operating pressure more than 2 psig.
- B. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.
- C. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with steel welding fittings and welded joints.

3.15 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:

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1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.
- C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.
- D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.
- E. Valves in branch piping for single appliance shall be one of the following:
1. Two-piece, full-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.

END OF SECTION 23 1123

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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. Plastic pipe and fittings.
 - 4. Joining materials.
 - 5. Transition fittings.
 - 6. 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.
 - 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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:

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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.
- 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.

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- I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

- A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.
 - 1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
- B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.
 - 1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 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. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for CPVC Piping: ASTM F 493.
 - 1. Solvent cement shall have a VOC content of 490 g/L or less.

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H. Solvent Cements for PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

1. Solvent cement shall have a VOC content of 490 g/L or less.

2.6 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.

2.7 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:
 - 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:

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- 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:
 - 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:

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1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
- G. Dual-temperature heating and cooling 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.
- H. Dual-temperature heating and cooling water 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.
- I. Dual-temperature heating and cooling 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.
 2. RTRP and RTRF with adhesive or flanged joints.
- J. Glycol cooling-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Type L Type M, 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.
- K. Glycol cooling-water 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.
- L. Glycol cooling-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.

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- M. Makeup-water piping installed aboveground shall be either of the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- N. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
- O. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- P. 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.
- Q. 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.
- 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.

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- 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.
- 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.

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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.

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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. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- H. 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.
- I. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

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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.

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4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 23 2113

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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 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
- 2. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
- 3. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
- 4. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
- 5. 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.

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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.

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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:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. Flow Design, Inc.
 - d. Griswold Controls.
 - e. HCL; 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.

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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. 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.

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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.
 - 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.

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- 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:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Spiro-Therm – Spirovent Air/Dirt Separator
 - b. SUBSTITUTIONS WILL NOT BE ACCEPTED.
 - 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. Omitted Addendum #2.
 - 4. Maximum Working Pressure: Up to 175 psig.
 - 5. ASME Rated.
 - 6. 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.

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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.

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- 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.
- 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

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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.
 - 4. Automatic condensate pump units.

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.

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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 tapings 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.

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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.

2.2 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.

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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.

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- 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.
 - 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.

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- 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.
- 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.

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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.
- 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.

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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.

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- 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. Condensate piping above grade, NPS 2 and smaller, shall be either of the following:

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1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- C. Low Pressure Steam Piping, NPS 2 inch and Larger:
 1. Schedule 40, Type E, Grade B, Steel Pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

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.

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- 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.

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- 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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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- 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.

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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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

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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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY
SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW
ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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- 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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

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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.

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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.

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6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
- 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.

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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.
 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 Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
- B. Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

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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.

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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:

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1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps and double risers to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
1. Shot blast the interior of piping.
 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 3. Draw a clean, lintless cloth, saturated with 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. Braze Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

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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.
 - 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.

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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.

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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.

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1. Include plans, elevations, sections, and attachment details.
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 Inc.
 2. Crown Solutions Inc.
 3. Certified Laboratories
 4. H-O-H Water Technology Inc.
 5. Watertech of America
 6. Butler Chemical Company
 7. Betz
 8. America's Best Water Treaters

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.

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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.
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.

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- 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.
 - 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."

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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.
 - 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.

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- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

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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.

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7. Penetrations through fire-rated and other partitions.
8. Equipment installation based on equipment being used on Project.
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."

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1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 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."

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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 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.

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- 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:

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1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 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.

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- 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.
- 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.

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- 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.

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3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 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:

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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:
 - 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.

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- 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.
 - 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.

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- b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- H. Branch Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

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- 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

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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. Indoor Textile Air Dispersion Products.
 - b. Outdoor Non-Metal Duct
- 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.

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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. Nanosox

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/ft² per ASTM D737, Frazier
 - c. Weight: 6.8 oz. /yd² 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

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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.
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.

2.3 FIBROUS GLASS DUCT AND FITINGS

A. Manufacturers Subject to compliance with requirements

1. Thermaduct

B. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.

1. Duct Board: Factory molded into rectangular boards.
2. Round Duct: Factory molded into straight round duct and smooth fittings.
3. Temperature Limits: 185 deg F ambient temperature surrounding ducts.
4. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg at 75 deg F
5. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C 1104/C 1104M.
6. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
7. The density of the Kooltherm foam shall not be less than 3.5 pcf (56 Kg/m3) with a minimum compressive strength of 28 psi (.2 MPa).
8. The standard panel is (31 mm) thickness panel with R-8.1 (1.5 RSI) shall be utilized un-

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less indicated otherwise on the print.

9. Antimicrobial Agent: Additive for antimicrobial shall not be used but instead, raw product must pass UL bacteria growth testing.
10. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
11. Required Markings: All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
12. R-value:
 - i. 1 3/4 (45 mm) Thick Panel: 12 R
 - ii. 2 1/16" Double wall (55 mm): 14.1 R
 - iii. 2 3/8" Double wall (62 mm) Thick Panel: 16.2 R
 - iv. 3" Double wall (76 mm) Thick Panel: 20.1 R
 - v. 3.5 Double wall (100 mm) Thick Panel 24 R

C. Closure Materials:

1. V-Groove Adhesive: Silicone (interior only).
2. UV stable 1000 micron high impact resistant titanium infused vinyl (exterior).
 - i. Factory manufactured seamless corners for zero perms.
 - ii. Cohesive bonded over-lap at corner seam covers for zero perms.
 - iii. Water resistant titanium infused welded vinyl seams.
 - iv. Mold and mildew resistant.
3. Polymetric Sealing System:
 - i. Structural Membrane: Aluminum scrim with woven glass fiber with UV stable vinyl clad applied
 - ii. Minimum Seam Cover Width: 2 7/8" inches (75 mm)
 - iii. Sealant: Low VOC.
 - iv. Color: White (colors, matched by architect optional).
 - v. Water resistant.
 - vi. Mold and mildew resistant.
4. Duct Connectors.
 - i. Factory manufactured cohesive bonded strips (low pressure only).
 - ii. Factory manufactured all aluminum grip flange.
 1. Grip flange
 2. F-flange
 3. H-flange
 4. U-flange
 - iii. Factory manufactured galvanized 4-bolt flange

D. Outdoor Cladding

1. Thermaduct outdoor Installations: Duct segments shall incorporate UV stable 1000 micron high impact resistant titanium infused vinyl which is introduced during the manufacturing process.

E. Reinforcement

1. Thermaduct shall provide designed and built with adequate reinforcement to both; withstand air pressure forces from within the duct from blower pressure and shall be built to handle expected snow load for the location where the Thermaduct is being installed. Thermaduct will employ Airtruss™ reinforcement system when both specified static pressure and duct sizes dictate the need. This is a factory installed system and no field installation of the reinforcement system is required.

F. Weight

1. Thermaduct shall provide low weight stresses on the building framing and support members. Assembled Thermaduct shall have a weight of 0.86 lbs. per square foot to maxi-

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imum weight of 2.7 lbs. per square foot (depending on R-value and reinforcement requirement). Hangers and tie-downs are to be detailed on the manufacturer's installing contractors detail drawings prior to installation but not exceeding 13' for duct girth <84" and 8' for duct girth >85" between hangers and designed to carry the weight and wind load of the ductwork.

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.

3.3 THERMADUCT SHOP FABRICATION:

- A. Certification:
 - 1. Ducts shall be detailed and fully factory manufactured by an authorized Thermaduct, LLC facility system. All fabrication labor will be certified "yellow label" building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).
- B. Fabrication:
 - 1. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer's written and detailed instructions.
 - 2. Fabricated 90-degree mitered elbows to include turning vanes.
 - 3. Fabricated duct segments in accordance with manufacturer's written details.
 - 4. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
 - 5. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer's detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer's design guide based on specified ductwork size and system pressure.
 - 6. Designed and fabricated duct segments and fittings will be in accordance with "SMACNA Duct Construction Standards" latest edition.
 - 7. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for

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- permanent protection against water intrusion.
8. Duct shall be constructed to exceed requirements for snow and wind loads.

3.4 THERMADUCT DUCT INSTALLATION:

- A. Duct segments shall be installed by competent HVAC installers.
- B. Install ducts and fittings to comply with manufacturer's installation instructions as follows:
1. Install ducts with fewest possible joints.
 2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
 3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
 4. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
 5. Use prescribed duct support spacing as described in this specification and manufacturer's recommendations.
- C. Air Leakage: Duct air leakage rates to be in compliance with "SMACNA HVAC Duct Construction Standards" latest version per applicable leakage class based on pressure.
- D. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

3.5 THERMADUCT HANGER AND SUPPORT INSTALLATION:

- A. Contractor to ensure that the ductwork system is properly and adequately supported.
1. Ensure that the chosen method is compatible with the specific ductwork system requirements per Thermaduct installation detail drawings. Pre-installation should be provided prior to work commencement by installing contractor for approval.
 2. 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.
- B. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13 foot (3.96 m) lengths with duct girth less than 84". Larger duct sizes and short segments with duct girth greater than 84" are to be supported at 8 foot centers or less, in accordance with the Thermaduct installation details provided prior to work commencement.
- C. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.
- D. The load of such accessories to the ductwork shall be neutralized by the accessory support.

3.6 FIELD QUALITY CONTROL:

- E. Inspection: Arrange for manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions
1. Remove and replace duct system where inspection indicates that it does not comply with specified requirements
- F. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.

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3.7 THERMADUCT DUCT SCHEDULE:

- G. Outdoor Ducts and Fittings:
 - 1. Thermaduct Rectangular Ducts and Fittings:
 - i. Minimum Panel Thickness: 45 mm
 - ii. Cladding: minimum 0.038 inch
 - iii. Insulation Rating: minimum R-12

END OF SECTION 233116

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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. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Combination fire and smoke dampers.
7. Corridor dampers.
8. Flange connectors.
9. Turning vanes.
10. Remote damper operators.
11. Duct-mounted access doors.
12. Flexible connectors.
13. 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.

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1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, 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.

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- 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 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a Mestek Architectural Group company.
 - 2. Cesco Products; a division of MESTEK, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Ruskin Company.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: 2-inch wg.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.050-inch-thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch.
- J. Tie Bars and Brackets: Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball or synthetic pivot bushings.
- M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.

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2. Chain pulls.
3. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage minimum.
 - b. Sleeve Length: 6 inches minimum.
4. Screen Material: Aluminum.
5. Screen Type: Bird.
6. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

- 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. Greenheck Fan Corporation.
 4. Nailor Industries Inc.
 5. NCA Manufacturing, Inc.
 6. Ruskin Company.
- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: 2-inch wg.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
- F. Blades:
 1. Multiple, 0.050-inch-thick aluminum sheet.
 2. Maximum Width: 6 inches.
 3. Action: Parallel.
 4. Balance: Gravity.
 5. Eccentrically pivoted.
- G. Blade Seals: Neoprene.
- H. Blade Axles: Galvanized steel.
- I. Tie Bars and Brackets:
 1. Material: Galvanized steel.
 2. Rattle free with 90-degree stop.
- J. Return Spring: Adjustable tension.

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K. Bearings: Synthetic.

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 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.

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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:

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.

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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:

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.

2.6 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:

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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.

2.7 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance; a division of MESTEK, Inc.
 2. American Warming and Ventilating; a Mestek Architectural Group company.
 3. Cesco Products; a division of MESTEK, Inc.
 4. Greenheck Fan Corporation.
 5. Nailor Industries Inc.
 6. NCA Manufacturing, Inc.
 7. Pottorff.
 8. Ruskin Company.
 9. United Enertech.
- B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 hours.
- E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.138 inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

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2.8 COMBINATION FIRE AND SMOKE DAMPERS

- 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. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff.
 - 6. Ruskin Company.
- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 hours.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.
- F. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- thick, galvanized sheet steel.
- G. Leakage: Class I.
- H. Rated pressure and velocity to exceed design airflow conditions.
- I. Mounting Sleeve: Factory-installed, 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- J. Damper Motors: Modulating or two-position action.
- K. 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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

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5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

L. Accessories:

1. Auxiliary switches for signaling fan control or position indication.
2. Test and reset switches, damper remote mounted.

2.9 FLANGE 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. 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.

2.10 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.

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- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vaness 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.

2.11 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.
- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Stainless steel.

2.12 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.

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- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.
- C. Pressure Relief Access Door:
- 1. Door and Frame Material: Galvanized sheet steel.
 - 2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
 - 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 - 4. Factory set at 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.

2.13 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.

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2.14 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.
 - 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.

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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.

2.15 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. 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.

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- 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.
 - 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.

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- 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

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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."

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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.

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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

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SECTION 23 3350

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.

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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:

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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.

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- 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

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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.

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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.
- 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.
 - 2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

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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. Chicago Blower Corporation.
2. COMEFRI.

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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.
- 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."

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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."
- B. Install ducts adjacent to fans to allow service and maintenance.

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- 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

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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.

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3. Carnes Company.
 4. Greenheck Fan Corporation.
 5. JencoFan.
 6. Loren Cook Company.
 7. PennBarry.
 8. ACME
 9. Soler & Palau
 10. Cames
- 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.

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5. JencoFan.
 6. Loren Cook Company.
 7. Peerless Blowers.
 8. ACME
 9. Soler & Palau
 10. Cames
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- 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."

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- 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.
- 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.

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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.
- 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

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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:

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- 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. Johnson Controls.
 - 5. Krueger.
 - 6. METALAIRE, Inc.
 - 7. Nailor Industries Inc.
 - 8. Price Industries.
 - 9. Titus.
 - 10. Trane.
- 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.

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- D. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero 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.

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3.2 TERMINAL UNIT INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- 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.

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3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 3600

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY
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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.

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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.

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- E. Dampers: Combination damper and grid.
- 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.

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- 6. Price Industries.
- B. Devices shall be specifically designed for variable-air-volume flows.
- 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.

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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.
 - 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.

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- 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:
 - 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.

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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

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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:

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- a. Anemostat Products; a Mestek company.
 - b. Carnes Company.
 - c. Hart & Cooley Inc.
 - d. Krueger.
 - e. METALAIRE, Inc.
 - f. Nailor Industries Inc.
 - g. Price Industries.
 - h. Metalaire
- 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.
 - h. Metalaire
- 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:

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- a. A-J Manufacturing Co., Inc.
- b. Anemostat Products; a Mestek company.
- c. Carnes Company.
- d. Hart & Cooley Inc.
- e. Krueger.
- f. METALAIRE, Inc.
- g. Nailor Industries Inc.
- h. Price Industries.
- i. Metalaire

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.
 - g. Metalaire
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.

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- h. Metalaire
 - 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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

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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.

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E. Galvanized-Steel 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.

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.

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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.

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- 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.

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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY
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SECTION 23 5123

GAS VENTS

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. Listed double-wall vents.

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 product.
- B. Shop Drawings: For vents.
 - 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. Detail fabrication and assembly of hangers and seismic restraints.

PART 2 - PRODUCTS

2.1 LISTED TYPE B AND BW VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Metal Products.
 - 2. FAMCO.
 - 3. Heatfab Saf-T Vent.

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4. Metal-Fab, Inc.
 5. Schebler Co. (The).
 6. Selkirk Corporation.
- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F continuously for Type B or 550 deg F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.
- D. Inner Shell: ASTM B 209, Type 1100 aluminum.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
 2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.2 LISTED SPECIAL GAS VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Heatfab Saf-T Vent.
 2. Metal-Fab, Inc.
 3. Security Chimneys International.
 4. American Metal Products.
 5. Schebler Co.
 6. Selkirk Corporation
- B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.
- D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
- E. Outer Jacket: Stainless steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

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1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed Type B and BW Vents: Vents for certified gas appliances.
- B. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- E. Lap joints in direction of flow.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 23 5123

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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:

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1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
 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. 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. 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.

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6. ITT Corporation.
 7. TACO Comfort Solutions, Inc.
- 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 tappings to shell before testing and labeling.
1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
- 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).

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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."
- 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."

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- 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.

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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.

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

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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.

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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.

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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 one of the following:
 1. Lennox Industries, Inc.; Lennox International.
 2. Rheem Manufacturing Company; Heating and Cooling Products.
 3. Ruud Air Conditioning Division.
 4. Daikin-McQuay
 5. JCI/York
 6. Carrier
 7. Trane
 8. Aeon
- 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.

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6. Liquid-line solenoid.
 7. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
 8. Thermostatic expansion valve.
 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.

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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.
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.

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- 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.

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- 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.

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- 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.
- 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

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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.

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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.

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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.

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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.
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.

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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 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. Aeon.
 4. Carrier
 5. Trane

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.

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- 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.

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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 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.

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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:
 - 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.

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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.
 - 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.

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- 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:
 - 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.

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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.
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

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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.
- 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.

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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.
- 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.

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- 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.

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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.
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

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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.

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2. York/JCI.
3. Aeon.
4. Carrier
5. Trane

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:

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- 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.
- 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.

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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 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.

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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 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.

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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].
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.

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- 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:
 - 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.

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- 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, 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."

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- 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.
- 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

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- 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."

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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.
- 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.

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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

- 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

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SECTION 23 7333.16

INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING 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 indirect, gas-fired heating and ventilating units.

1.3 DEFINITIONS

- A. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.
 - 1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
 - 2. Include plans, elevations, sections, and mounting details.
 - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
 - 5. Include diagrams for power, signal, and control wiring.

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1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For indirect-fired heating and ventilating 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 unit.

1.7 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."

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Hastings HVAC; Division of Eric, Inc.
 - 3. I.C.E. Manufacturing Ltd.; Industrial Commercial Equipment - I.C.E. (US), Inc.
 - 4. Aaon

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5. Modine
6. Weather-Rite
7. Trane
8. Carrier

2.2 SYSTEM DESCRIPTION

- A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and indirect-fired gas burner to be installed inside the building.
- 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.

2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings:
 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 3. Factory Finish for Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 4. Casing Coating: Powder-baked enamel.
 5. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
 6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Configuration: Horizontal unit with horizontal discharge for suspended installation.
- C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet.
- D. Outer Casing: 0.0598-inch- thick steel with heat-resistant, baked-enamel finish over corrosion-resistant-treated surface in color to match fan section.
- E. Inner Casing:
 1. Burner Section Inner Casing: 0.0299-inch steel.
 2. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on burner and fan sections only.
 - a. Thickness: 1 inch.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - c. Density: 1.5 lb/cu. ft..

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- d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

F. Casing Internal Insulation and Adhesive:

- 1. Materials: ASTM C 1071, Type I.
- 2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.
 - a. Liner Adhesive: Comply with ASTM C 916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive, mechanical, 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 airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
- 3. Location and Application: Encased between outside and inside casing.

G. 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: Inspection and access panels.
 - b. Coil Section: Inspection and access panels.
 - c. Damper Section: Inspection and access panels.

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- d. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.

2.4 SUPPLY-AIR FAN

- A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings, rated for L50 or 200,000 hours with external grease fittings.
- B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
- C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, spring isolators.
- D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.5 AIR FILTERS

- A. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 6 according to ASHRAE 52.2.
 - 1. Thickness: 1 inch.
 - 2. Media: Interlaced glass polyester fibers.
 - 3. Frame: Galvanized steel.

2.6 DAMPERS

- A. Outdoor-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. of damper area, at a differential pressure of 2-inch wg.
- B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.7 INDIRECT-FIRED GAS BURNER

- A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."
 - 1. CSA Approval: Designed and certified by and bearing label of CSA.
 - 2. Burners: Stainless steel.
 - a. Gas Control Valve: Two stage.
 - b. Fuel: Natural gas.
 - c. Minimum Combustion Efficiency: 80 percent.

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- d. Ignition: Electronically controlled electric spark with flame sensor.
- B. Venting: Gravity vented.
- C. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
- D. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
- E. Heat Exchanger: Stainless steel.
- F. Heat-Exchanger Drain Pan: Stainless steel.
- G. Safety Controls:
 - 1. Vent Flow Verification: Differential pressure switch to verify open vent.
 - 2. Control Transformer: 24-V ac.
 - 3. High Limit: Thermal switch or fuse to stop burner.
 - 4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - 6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
 - 7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - 8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - 9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.8 CONTROLS

- A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.
- B. Control Devices:
 - 1. Remote Thermostat: Adjustable room thermostat with temperature readout.
 - 2. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
- C. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.
- D. Fan Control: Timer starts and stops indirect-fired heating and ventilating unit and exhaust fan(s).

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- E. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
- F. Temperature Control: Operates gas valve to maintain supply-air temperature.
 - 1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
 - 2. Operates gas valve to maintain space temperature with wall-mounted, field-wired sensor with temperature adjustment, and adjustment on remote-control panel.
 - 3. Timer shall select remote setback thermostat to maintain space temperature at 70 deg F.
 - 4. Burner Control: Two or four steps of control using one or two burner sections in series.
 - 5. Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

2.9 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."
 - 1. Enclosure: Totally enclosed, fan cooled.
 - 2. Enclosure Materials: Cast iron.
 - 3. Efficiency: Premium efficient.
 - 4. NEMA Design: B.
 - 5. Service Factor: 1.15.

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 indirect-fired heating and ventilating units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 INSTALLATION

- A. Unit Support: Install heating and ventilating unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.
- B. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- C. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.
- D. Duct Connections: Connect supply and return ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
- E. Ground equipment 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. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.

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- C. Units will be considered defective if they do 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.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to burner combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Purge gas line.
 - g. Inspect and adjust vibration isolators.
 - h. Verify bearing lubrication.
 - i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - j. Adjust fan belts to proper alignment and tension.
 - k. Start unit according to manufacturer's written instructions.
 - 2. Complete startup sheets and attach copy with Contractor's startup report.
 - 3. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 4. Operate unit for run-in period recommended by manufacturer.
 - 5. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - 6. Calibrate thermostats.
 - 7. Adjust and inspect high-temperature limits.
 - 8. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 - 9. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - 10. Measure and record airflow. Plot fan volumes on fan curve.
 - 11. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.

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12. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
13. Verify drain-pan performance.
14. Verify outdoor-air damper operation.

3.6 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. 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.

3.7 DEMONSTRATION

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

END OF SECTION 23 7333.16

SECTION 23 7343.16

OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes outdoor, semi-custom air-handling units that are factory assembled using multiple section components, including:
 - 1. Unit casings.
 - 2. Fan, drive, and motor section.
 - 3. Coil section.
 - 4. Air filtration section.
 - 5. Air Blender.
 - 6. Dampers.
 - 7. Roof curbs.
 - 8. Intake and relief air openings.
- B. Modified commercial and/or modular models are not allowed.

1.2 QUALITY ASSURANCE

- A. Unit shall bear ETL label.
- B. Products and execution shall be in compliance with applicable codes and standards including those referenced above in paragraph entitled *REFERENCES*.
- C. Installation, start-up and operation shall be in compliance with Manufacturer's requirements, recommendations, and Installation Operation and Maintenance guides (IOM).

1.3 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include AMCA certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - 6. Include AHRI 410 certified coil-performance ratings with system operating conditions indicated.

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7. Include AHRI Standard 1060 and ASHRAE Standard 84 certified Recovery device performance ratings with system operating conditions indicated.
 8. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each outdoor, semi-custom air-handling unit.
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. Detail fabrication and assembly of outdoor, semi-custom air-handling units, as well as procedure and diagrams.
 4. Include diagrams for power, signal, and control wiring.
- C. Exterior surfaces and floor of conditioned sections shall not condense given following conditions:
1. Unit interior air conditions
 - a. Lowest design operating temperature or 55 degrees
 2. Unit exterior ambient air conditions. Heat transfer and non-condensing requirements shall be satisfied at both operating conditions.
 - a. 95 F DB/78 F WB
 - b. 80 F DB/78 F WB

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 23 0548 "Vibration and Seismic Controls for HVAC."
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Source quality-control reports.
- D. Contractor Startup Service Reports.
- E. Contractor Field quality-control Reports.

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.

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1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Entire Unit: Manufacturer's standard but not less than one year(s) from date of Substantial Completion or 18 months from ship date.
 2. Warranty Period for Heat Wheels: Not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Daikin Applied.
 2. Trane
 3. Carrier
 4. York/JCI

2.2 GENERAL

- A. Custom air handling unit located in the basement complete with fans, coils, filters, damper, VFDs, piping and wiring for a complete and functional system.
- B. All joints shall be sealed via inherent self-sealing design or with non-permeable gasket material. Liquid or "flowable" Caulk, elastomeric tape, mastic, etc. shall not be used as primary sealing method.
- C. Unit shall have true thermal break construction with no metal-to-metal path for heat transfer.
- D. Proof of thermal break design including but not limited to computational thermal modeling software shall be submitted to the EOR for consideration and review (10) business days prior to Bid. Submitting does not guarantee acceptance for Bidding.
- E. Unit shall be factory assembled and tested prior to shipment. Unit capacities and performance shall meet or exceed the more stringent of that listed in schedule or within these specifications.
- F. Temperature controls shall be provided by others on site after installation of the unit. Refer to specifications Section 23 0923 and 230993.11 for additional information.
- G. All lighting, receptacles and wiring shall be provided and installed by unit manufacturer. Note: VFD's and Starters are by electrical contractor, refer to the electrical drawings and specifications.
- H. No component used in the manufacture of this unit shall have a flame spread/smoke developed rating greater than 25/50 when tested under ASTM E-84 and UL 723. All components shall also comply with NFPA 90 and 90B.

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2.3 UNIT CASINGS

- A. Housing shall be constructed in a watertight and airtight manner. Leakage shall not exceed 1% of total capacity at design static pressure. Construction shall result in an ASHRAE/ANSI standard 111 leakage class of less than 9 for single piece units and less than 12 for sectional units as measured in accordance with AMCA standard 210.
- B. General Fabrication Requirements for Casings:
 - 1. Formed metal panels with tongue & groove construction, or other means and methods that coheres with paragraph 2.6, thermal break.
 - 2. A structural frame shall form an integral structure when assembled with the wall panels.
 - 3. Formed intermediate cross flooring members shall be a minimum construction of commercial quality to rolled 11-gauge sheet steel complying with ASTM A569.
 - 4. Provide 12" C-Channel perimeter base frame with electrically welded integral lifting lugs, fabricated from structural steel with appropriate rigging hole. Lifting lug shall be removable.
 - 5. Provide angle welded to the internal perimeter base frame to provide reinforcement for the curb.
 - 6. Finish base frame, after fabrication with minimum of 1.5 mils of corrosion resistant epoxy primer with Pencil hardness B, sixty-degree gloss of less than or equal to 40 for proper finish adhesion and adhesion shall comply with ASTM D-3359-B with no lifting.
 - 7. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two coat, (1) coat DTM acrylic primer and (2) coats DTM acrylic finish paint coating, or baked-on enamel finish, consisting of prime coat and thermosetting topcoat. Engineer shall select preferred standard color option.
- C. Multi Section Units
 - 1. Design and manufacture units to facilitate field assembly.
 - 2. Provide demount sealing gaskets at all joints.
 - 3. Internal lifting eyes shall be provided such that mating sections can be set together without sliding.
 - 4. Mating of upper frame of each section shall be fabricated with a flange perimeter.
 - 5. Flanged perimeter shall be drilled with assembly clearance holes with continuous gasketing.
 - 6. Demount gaskets shall be high quality weather resistant closed cell neoprene elastomeric rubber.
 - 7. The exterior of the unit shall not have any standing seams or ridges and shall be factory primed and painted.
- D. Floor sheets shall be a minimum of 10-gauge tread plate epoxy coated carbon steel (or 1/8" aluminum tread plate) continuously welded or screwed to floor structure. Wall panels shall be continuously caulked to floor. Floors shall be turned up at all sides and ship splits with continuously welded joints. Floor shall be coated with a durable protective coating of zinc. Thickness shall conform to ASTM A527 for lock-former quality. Zinc coating weight shall be G-90 as per ASTM A525.
- E. Floor shall be double wall and insulated with the higher R value of a minimum of 2" thick polyurethane closed cell foam, R-Value of 13 or as described under 2.6 Thermal Break.

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- F. All segments referenced on drawings as having a sloped floor shall be 12-gauge stainless steel and pitched at a minimum of three directions towards a side outlet. Cap opening for field connection.
- G. Floor shall be constructed to prevent "oil canning".

2.4 ROOF AND WALL PANEL CONSTRUCTION

- A. All roof, panel and floor construction used for interior AHU walls shall be same construction and thickness as exterior AHU roof, panel and floor construction.
- B. All steel panel surfaces, and trim shall be fabricated from G-90 zinc coated steel.
- C. All exterior roof, and most interior panels shall be double wall construction as shown on the drawings.
- D. All exterior panels and roof shall be a minimum 2" thick, polyurethane closed cell foam, R-Value 13.
- E. Floor and walls shall deflect no more than 1/200 of span at unit operating pressures.
- F. Panel corners shall be caulked with sealant.
- G. After insulation, liners shall be permanently attached to the outer shell.
- H. Panels shall be sealed with an industrial neoprene gasket to form a water and airtight seal with the roof. Fasteners shall not penetrate into the air streams.
- I. Panel joints shall be recessed with minimal mechanical fasteners to complete panel assembly, no fasteners shall penetrate into the airstream.
- J. Panels shall be fabricated of 16-gauge sheet steel outer shell with 20 gauge solid sheet steel inner liner. All sheet steel shall be continuously hot dipped coated with durable protective coating of zinc. The steel shall conform to ASTM A527 for lock former quality. Zinc coating weight shall be G-90 as per ASTM A525.
- K. Include all insulated partitions such as those separating fan suction from fan discharge and other necessary to mount dampers, etc.
- L. Seal all joints and trim with UL-classified duct sealant.
- M. Inner liner shall be solid bright galvanized.
- N. If additional reinforcement of the unit structure is required for any reason, the manufacturer shall detail this additional reinforcement on the shop drawings.
- O. If columns and beams are required to support the roof panels serving the unit in lieu of using the wall panels, the manufacturer shall detail them in the shop drawings. Columns and beams shall not interfere with equipment in the housing.

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- P. Once unit sections are assembled provide rib caps at each joint and continuously caulk both sides prior to installation.
- Q. Where roof panels slope in two directions provide rib cap and roof peak cap at peak installed per manufacturers recommendations. Minimum pitch of roof shall be $\frac{1}{4}$ " in 12". Roof shall be finished in a method that it is watertight to provide zero water leakage into air tunnel.

2.5 STRUCTURAL SUPPORT

- A. Provide internal structural supports developed from angle, channel or tube steel shapes.
- B. Structural steel shall be continuously hot dip coated with a durable protective coating of zinc. Thickness shall conform to ASTM A527 for lock former quality. Zinc coating weight shall be G-90 as per ASTM A527.
- C. Seal around all attachments of structural steel to wall panel construction.

2.6 THERMAL BREAK

- A. All Exterior and Interior Casing (including roof and floor) shall be constructed with thermal break design based on No-Thru Metal construction.
- B. Overall Thermal "U" Value of the panels, roof, floor shall not exceed $0.0513 \text{ Btu/hr-ft}^2\text{-deg F}$ at 50 deg F Mean Temp. difference at Mid-panel or Mid-floor composition. Overall "U" Value at any seam, joint, split, edge, support etc. with air / air contact of the assembled Unit/Structure shall not exceed $0.075 \text{ Btu/hr-ft}^2\text{-deg F}$ at 50 deg F Mean Temp. difference and shall not exceed $0.0513 \text{ Btu/hr-ft}^2\text{-deg F}$ at 50 deg F Mean Temp. difference for areas of surfaces in contact with water i.e.) recessed drain pans and other flooring able to retain or channel water.

2.7 ACCESS DOORS

- A. Provide doors as indicated on the drawings.
- B. Doors shall be minimum 24" wide by 72" high with double panel window unless detailed otherwise.
- C. Doors shall be same gauge and thickness as the unit housing: double wall and completely insulated similar to housing.
- D. Each door shall have three (3) eccentrically pivoted 3-way adjustable hinges.
- E. Each door shall have a minimum of two (2) Ventlok high compression latches or Allegis K2 nylon door latches, operable from both sides.
- F. Door shall be fully gasketed with continuous neoprene/EPDM rubber bulb type with internal aluminum clips and rated for a constant exposure temperature range of -20 deg F to 160 deg F while maintaining elastic compression characteristics.

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- G. Doors shall swing open against the section pressure.
- H. Provide minimum 8" x 8" wire glass window in the door near the top.

2.8 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. Direct Drive Fan Assembly.
 - 2. 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. Fan Guards: Fan inlet and outlet shall be covered OSHA wire guards.
- D. Airfoil, Centrifugal Fan Wheels:
 - 1. Fan wheels shall be direct drive plenum fan with 12-bladed airfoil wheel of all aluminum construction.
 - 2. Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades
 - 3. Continuously welded at tip flange and backplate.
- E. 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.
- F. 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.
- G. 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 16 Sections.

2.9 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.

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- 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 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.

2.10 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 continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.

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- 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 Red Brass 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.

2.11 ENTHALPY RECOVERY WHEEL

- A. Performance
 - 1. Manufacturer shall provide certified performance data in accordance with ASHRAE Standard 84 and AHRI 1060. Independent performance test results shall be used to rate product in accordance with AHRI Air-to-Air Energy Recovery Ventilation Equipment Program.
- B. General Requirements
 - 1. Casing
 - a. Rotor casing shall be provided with structural framework to rigidly support rotor.
 - b. Casing sheet metal shall be reinforced as required to provide solid mounting surface for peripheral and radial seals
 - 2. Rotor
 - a. Rotor frame shall be hub, spoke and rim system constructed of extruded aluminum.
 - b. Rotor shall not deflect in excess of 1/32" from no-flow condition to full design airflow condition. Deflection shall be measured at rim of wheel where exposed to greatest force of airflow. Deflection shall be measured relative to wheel support frame.

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- c. Rotor design shall allow replacement of media segments in field conditions without removal of rotor.
 - d. Anti-rotation feature shall be provided to prevent reverse rotation.
 - e. Energy recovery wheels that require field assembly shall be assembled by service personnel in direct employ of Manufacturer, no exceptions
- 3. Rotor Bearings
 - a. Rotor shall be supported by two pillow block bearings that can be maintained and replaced without disassembly of rotor.
 - b. Bearings shall provide L10 life of 1,000,000 hours operation
- 4. Rotor Seals
 - a. Face seal and perimeter seal shall be provided to prevent cross leakage between two air streams
 - b. Seals shall be field adjustable non-contact labyrinth type.
 - 1) Factory fabricated field adjustable purge unit shall be provided even if the application calls for recirculation damper. (Future System revisions may delete recirc Damper.)
 - 2) Purge shall be designed to be able to limit cross contamination to less than 0.1% of exhaust stream concentration at any operating condition for standard (no-recirculation Damper) applications (As well, on the basis the Recirculation Damper is fully closed or potentially removed from System/design). Cross contamination shall be limited to 0.04% for laboratory fume hood applications or other systems conveying toxic or noxious vapors. In which case Such Design shall not employ any recirculation Damper.
- 5. Drive
 - a. Rotor shall be driven by belt system and electric gear motor, VFD compatible.
 - b. Variable speed control of wheel for capacity and frost control shall be accomplished via use of VFD. VFD shall comply with Section 26 29 23 - Variable Frequency Motor Controllers for VFD requirements. VFD to be provided by Electrical Contractor.
- 6. Coating
 - a. All metal surfaces shall be provided with corrosion resistant coating, and an anti-stick and anti-microbial face coating.
- 7. Filters
 - a. Filtration shall be provided upstream of energy recovery wheel in each air path. As indicated within filter specification above, filters shall be front loading 4" pleated type, MERV 8.
 - b. Filter assembly shall comply with requirements presented above in paragraph entitled Filters.
- 8. Bypass Dampers
 - a. Without exception, automated dampers shall be provided in both air streams at each energy recovery wheel (i.e. outdoor/supply, return/exhaust) to enable bypass of air when wheel is not active to reduce air pressure drop, facilitate economizer operation and provide frost control. Dampers shall be sized such that combined airflow through damper and wheel is sufficient for 100% outdoor air economizer.
 - b. Bypass dampers shall comply with requirements presented above in paragraph entitled Control Dampers and Actuators.
- 9. Controls
 - a. Provider of Wheel Controls
 - 1) All controllers, associated control devices and programming shall be provided by Temperature Control Contractor in accordance with requirements of Section 23 09 23 – Direct Digital Control System for HVAC and Section 23 09 93.11 – Sequence of Operation for HVAC DDC.

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- 2) All controllers, associated control devices and programming shall be compatible with requirements of Section 23 09 23 – Direct Digital Control System for HVAC and Section 23 09 93.11 – Sequence of Operation for HVAC DDC.

C. Media

1. Total Enthalpy Wheel

- a. Wheel shall equally provide both sensible and latent heat recovery. Sensible and latent heat transfer effectiveness shall meet or exceed scheduled values.
- b. Energy recovery effectiveness values shall be tested in accordance with ASHRAE 84 and shall be certified in accordance with AHRI Standard 1060.
- c. Media shall consist of corrugated aluminum foil substrate coated with molecular sieve desiccant or ion exchange resin configured into honeycomb structure. Edges shall have anti-corrosion coating.
- d. Corrugations shall have high surface area per volume to ensure no fouling occurs on internal heat transfer surface. Dry particles up to minimum of 800 shall freely pass-through media.
- e. Molecular sieve and ion exchange resin coating shall be designed to selectively transfer water vapor while allowing other gaseous chemicals to pass.
 - 1) For standard applications, including laboratory general exhaust:
 - a) The only modification shall be Molecular sieve desiccant internal pore diameter shall limit absorption to materials having 4 angstrom kinetic diameter or less.
 - b) Ion resin shall provide same or better performance in all regards and comply with same certifications
- f. Media shall be cleanable with low temperature steam (less than 5 PSI), hot water or light detergent solution without degrading latent recovery.
- g. Dry particles up to 800 microns shall pass freely through the media.
- h. Media shall have flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E-87.

D. Sizing

1. Heat wheel shall be sized to yield average face velocity not to exceed 800 FPM.
2. Total, Sensible and Latent Effectiveness calculations with ASHRAE 84 and shall be certified in accordance with AHRI Standard 1060 shall be provided and clearly demonstrate equal (to within 1% roundoff) sensible and Latent Effectiveness ratios using each Enthalpy, Grains, dry-bulb F input and output conditions.
3. Efficiency Calculations as per ASHRAE 90.1 6.5.6.1 shall meet or exceed 50% recoverable total energy
 - a. enthalpy recovery ratio: change in the enthalpy of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air enthalpy, expressed as a percentage
 - b. sensible energy recovery ratio: change in the dry-bulb temperature of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air dry-bulb temperatures, expressed as a percentage
4. AHRI Guideline V shall be used in selecting the wheel to achieve the best RER i.e.) a metric developed to report: “recovered energy divided by the power used to recover that energy” the RER can be used as a method to compare energy recovery devices. This metric reflects the impact of pressure loss (fan power) and wheel drive power. RER_{total} reflects total recovery at cooling or heating design conditions, expressed in BTUs/Watts. A higher RER value reflects a more efficient overall system design.

2.12 AIR BLENDER

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- A. Air Mixer shall be of .081" aluminum, 304 or 316 stainless steel construction of size, performance and maximum pressure drop indicated. The panel shall be fabricated of 18 galvanized steel (or of the same material and finish as the Mixer). The Air Mixer shall mix two or more airstreams of differing temperature to within +/- 6 degrees Fahrenheit of the theoretical mixed air temperature and provide a more uniform air velocity contour entering a downstream filter or coil bank.

2.13 FILTERS

- 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.

2.14 SUPPLY, RETURN, RELIEF AND OUTDOOR AIR 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.
- K. All exterior dampers shall be covered by a weather hood sized to prevent snow or water penetration.

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2.15 ELECTRICAL

- A. All fans motors shall be factory wired to junction boxes located on the exterior of the unit. Fan motors requiring wire run in EMT shall have a 2' length of seal tight at the motor junction box.
- 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. Low voltage wiring shall use plenum cable, 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.

2.16 CONTROL HARDWARE

- A. All controls for air-handling units shall be field installed by temperature control contractor refer to Specification Section 23 0923 and 230993.11 for requirements.

2.17 SERVICE LIGHTS & GFI RECEPTACLE

- A. Vapor tight 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.

2.18 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, GENERAL

- A. Unit Support: Install unit level on structural steel supports. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of steel supports with actual equipment provided.
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- C. 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.
- D. 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.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 3300 "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 space for maintenance and slide out removal of coils.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/2, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof 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 23 2113 "Hydronic Piping" and Section 23 2116 "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.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

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- 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 26 0553 "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 26 0523 "Control-Voltage Electrical Power Cables."

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service. Provide full coordination with other Trades and Equipment Providers such that this Service Representative may complete these tasks without delay or encumbrance.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Contractor Verify that shipping, blocking, and bracing are removed.
 - 3. Contractor 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.C
 - 4. Ensure Contractor has verified proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Contractor 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. Ensure Contractor has verified that zone dampers fully open and close for each zone.
 - 7. Ensure Contractor has verified that face-and-bypass dampers provide full face flow.
 - 8. Ensure Contractor has verified that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - 9. Comb coil fins for parallel orientation.
 - 10. Ensure Contractor has verified that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures (enabled and operated by Respective Trade) 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.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

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3.8 CLEANING

- 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.

3.9 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.
- E. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
- F. Prepare test and inspection reports.

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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

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- 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 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.

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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.
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.

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2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AAON.
 - 2. Daikin Applied.
 - 3. JCI/York.
 - 4. Carrier
 - 5. Trane

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.

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- 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.
- 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.

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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.
 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.

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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.

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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:
 - 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.

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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.
 - 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.

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- 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.
 - 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.

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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."
- 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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- 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.
 - 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.

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- 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.
 - 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.

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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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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."

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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
 - 10. Carrier
 - 11. Trane
- 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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3.2 INSTALLATION

- A. Install coils level and plumb.
- 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

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY
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SECTION 23 8216.12

STEAM AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Steam air coils.

1.2 ACTION SUBMITTALS

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

1.3 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.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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: 100 psig/400 deg F.
- D. Capacities and Characteristics:
 - 1. Air Side:
 - a. Entering Temperature: 55 deg F.
 - 2. Steam Side:
 - a. Inlet Pressure: varies, see equipment schedule on drawings.

2.2 STEAM AIR COILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
 2. Greenheck Fan Corporation.
 3. RAE Coils; a division of RAE Corporation.
 4. Trane.
 5. Commercial Coils, Inc.
- B. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die-formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.
1. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube, to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
 2. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube
- C. Tubes:
1. Material: Copper.
 2. Nominal Diameter: Minimum 5/8 inch before expanding, selected to provide performance indicated.
 3. Nominal Wall Thickness: As required by performance, minimum .035 in thick.
- D. Fins:
1. Type: Plate.
 2. Materials:
 - a. Aluminum: .008 in 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: Fin type as required by performance requirements.
 6. Fin and Tube Joint: silver brazed.
- E. Headers:
1. Material: extra heavy seamless copper tubing with brazed joints.
 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.

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4. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
- F. Casings:
1. Casings shall be constructed of continuous stainless steel. Coil side plates shall also be continuous steel of reinforced flange type for duct mounting.
- G. 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 fin material and thickness.
 9. Coil tube material and thickness.
 10. Coil header material and thickness.

2.3 SOURCE QUALITY CONTROL

- A. Steam Coils: Factory tested to 300 psig.
- 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. Straighten bent fins on air coils.

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- D. 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 steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control valves are specified in Section 23 0923.11 "Control Valves," and other piping specialties are specified in Section 23 2213 "Steam and Condensate Heating Piping."

END OF SECTION 23 8216.12

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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4. IEC (International Environmental Corporation); LSB Industries.
 5. Titus.
 6. York/JCI.
 7. Aaon.
 8. Carrier
 9. 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.

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- 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.
- 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.
 - 8. Carrier

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9. 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 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.
 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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL, AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL, AND FAIRVIEW EARLY CHILDHOOD CENTER
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- 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."
- 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.

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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.
- 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.

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- 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

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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:

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- 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

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- C. Magic-Aire
- D. Trane
- 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.

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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.
- 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."

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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.
- 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.

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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.

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- 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."
- 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.

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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

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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 and electric, 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.

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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 ELECTRIC FINNED-TUBE RADIATION HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berko; Marley Engineered Products.
 - 2. Chromalox, Inc.
 - 3. INDEECO.
 - 4. Markel Products; TPI Corporation.
 - 5. Marley Engineered Products.
 - 6. Ouellet Canada Inc.
 - 7. QMark; Marley Engineered Products.
 - 8. Sigma Corp.
 - 9. Zehnder-Rittling
 - 10. Vulcan
- B. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
 - 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.
- C. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
- D. Rust-Resistant Front Panel: Minimum 0.064-inch- thick, ASTM A 653/A 653M, G60 galvanized steel.

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- E. Wall-Mounted Back Panel: Minimum 0.0329-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.
- F. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch spacing. Pedestal-mounted back panel shall be solid panel matching front panel.
- G. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- H. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
- I. Damper: Knob-operated internal damper at enclosure outlet.
- J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- K. Enclosure Style: Flat top.
 - 1. Front Inlet Grille: Punched louver; painted to match enclosure.
 - 2. 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.
 - 3. Top Outlet Grille: Punched louver; painted to match enclosure.
 - 4. 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.
 - 5. Enclosure Height: Refer to equipment schedules.
 - 6. Enclosure Depth: Refer to equipment schedules.
- L. Unit Controls: Integral low-voltage relay and control transformer for remote thermostat.
- M. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

2.2 HOT-WATER FINNED-TUBE RADIATION HEATERS

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

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2. Engineered Air.
 3. Hydro-Air Components Inc.
 4. Quincy Hydronic Technology Inc.
 5. Rosemex Products.
 6. Slant/Fin Corp.
 7. Sigma Corp.
 8. Modine
- 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.
- 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.

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- 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.

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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:
 - 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

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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 electrical resistance coils or 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.

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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. INDEECO.
 6. Markel Products; TPI Corporation.
 7. Marley Engineered Products.
 8. QMark; Marley Engineered Products.
 9. Sigma Corp.
 10. Daikin Applied
 11. Zehnder-Rittling
 12. Vulcan
 13. Trane
 14. Carrier

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.

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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 7.

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.

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- B. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

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.

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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.
- 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.

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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.

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

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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. Trane
 - 10. Carrier

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.

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- 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.

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- 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."
- 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:

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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.

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

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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.

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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

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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.

- 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.

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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.

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- 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.
- 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

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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

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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.

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

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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:

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1. Alcan Products Corporation; Alcan Cable Division.
 2. American Insulated Wire Corp.; a Leviton Company.
 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.

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- 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 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.

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D. Remove and replace malfunctioning units and retest as specified above.

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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.

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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.

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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.
 - 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.

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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.
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.

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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

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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.

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- 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.

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- E. Conduit Hubs: Mechanical type, terminal with threaded hub.
- 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.

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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.

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- 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.
 - 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.

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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.

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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 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

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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."

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- 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.

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2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. 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.

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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.

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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

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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.

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2. Alflec Inc.
 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 5. Electri-Flex Co.
 6. Manhattan/CDT/Cole-Flex.
 7. Maverick Tube Corporation.
 8. O-Z Gedney; a unit of General Signal.
 9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. 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.

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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:

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1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. RACO; a Hubbell Company.
 8. 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.

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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.
 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.

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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.
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

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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.

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2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
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:

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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.
- 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.

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- 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.

2.4 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.

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- 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.

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- 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.

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- 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.

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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.
- 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.

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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.
 - 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

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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.
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.

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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.

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- 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:
 - 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

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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:

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- 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 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.

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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:

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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.
- 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

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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

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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

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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

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study data to ensure that the selection of devices and associated characteristics is satisfactory.

- 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.

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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.
- 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.

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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.
 - 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.

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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.
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.

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- 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.

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

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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.

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PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:

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.

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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:
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.

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- 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 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:

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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.

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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.
 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.

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2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
10. 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.

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- 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.
- 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

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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.

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- 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.

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- 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.

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2. Protective device clearing time.
 3. Duration of arc.
 4. Arc-flash boundary.
 5. Working distance.
 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.

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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.
- 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.

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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.
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:

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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.

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

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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.

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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.

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- b. When significant daylight is present (target level).
 - c. System programming is done with two hand-held, remote-control tools.
- 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.

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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:
 - 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.

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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.
 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.

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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.
 - 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.

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- 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.
- 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.

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- 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.
 - 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

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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."

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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 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.

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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.
- 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.

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- 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.

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3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 2200

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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 graft 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:

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1. Do not deliver or install switchboards until wet work in spaces is complete and dry, and work above switchboards is complete.
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.

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B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Panel mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: 480Y/277 V.

D. 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.

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2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. 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.

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- 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.
- 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.

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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:
 - 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.

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- 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

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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.

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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.

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- b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 - 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.

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- 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.

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- 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.
- 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.

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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.

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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

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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."

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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:

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1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. 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.

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1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 2726

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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.

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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.

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- 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

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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.

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B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
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.

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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.
- 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.

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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.

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- 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.
- 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.

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- 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.

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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.
 - 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:

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- 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:

- 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.

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- 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:
 - 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.

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- 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

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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.

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1.3 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a 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.

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- 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.

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PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 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

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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.

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1. Include dimensions and finishes for VFCs.
 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.

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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.

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- 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 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.

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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.
 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

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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).

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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:

- 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.

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- 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 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.

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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.
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.

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- 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.
 - 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.

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- 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.
 - 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.

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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."
- 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.

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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.
 - 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.

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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.

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

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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.

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- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE 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.

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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:
 - 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.

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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:
 - 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.

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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

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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.

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3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
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.

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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.

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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.

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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.

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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.

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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:
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.

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- 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

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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.

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2. LED Drivers: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
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.

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- B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.
- E. 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.

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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.
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.

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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.

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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.

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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:

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

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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

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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.

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2.5 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.
 - 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.

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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.
 - 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.

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- 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.
 - 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.

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- 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

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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.

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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.

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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.

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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

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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.

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- 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.

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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.

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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.
 - 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."

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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.

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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.
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:

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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.
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.

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- 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.
 - 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.

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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.
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

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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.

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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.

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2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 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.

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2.5 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.
- 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.

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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."

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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.
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.

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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:
 - 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

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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.

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- 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:
 - 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

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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.

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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.
 - 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:

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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.

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- 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.
 - 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.

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**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."

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

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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:

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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.

ESSER HVAC UPGRADES TO JOHNSON ELEMENTARY SCHOOL, CONKLIN ELEMENTARY SCHOOL,
AUBURN HIGH SCHOOL, FROBERG ELEMENTARY SCHOOL, WEST VIEW ELEMENTARY SCHOOL,
AND FAIRVIEW EARLY CHILDHOOD CENTER
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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.

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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 28 0544