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WSP USA Buildings, Inc.
Firm Registration number: Missouri 2013001881

**MECHANICAL ENGINEER'S SEAL**


**ELECTRICAL ENGINEER'S SEAL**


## DIVISION 00 – BIDDING REQUIREMENTS



## DIVISION 01 – GENERAL REQUIREMENTS

**END OF INDEX**

# SECTION 00100

# INSTRUCTIONS TO BIDDERS

## PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract and Division 1 - General Requirements are collectively applicable to this Section.

1.2 PROJECT DESCRIPTION

A. Owner will receive Proposals for the Domestic Water System Replacement project for the existing HCA Lee's Summit Medical Center located at 2100 SE Blue Pkwy, Lee's Summit, MO 64063.

1.3. PROPOSAL DUE DATE

A. Proposals must be received by 4:00 PM, April 25, 2024, and shall be e-mailed to:

WSP
Attn: Mr. Ben Sitzia ben.sitzia@wsp.com
200 Wyandotte, Suite 200
Kansas City, Missouri 64105

1.4. DEFINITIONS

A. All definitions set forth in the General Conditions of the Contract for Construction, AIA Document A-201, latest edition, are applicable to these Instructions to Bidders.

B. Bidding documents include the Instructions to Bidders, the bid forms, and the proposed Scope Package necessary for a Guaranteed Maximum Price to be established.

C. Addenda are written or graphic instruments issued prior to the execution of the Contract which modify or interpret the bidding documents, including Drawings and Specifications, by additions, deletions, clarifications or corrections. Addenda will become part of the Contract Documents when the Construction Contract is executed.

D. A Bid is a complete and properly signed proposal to do the Work for designated portion thereof for the sums stipulated therein, submitted in accordance with the Bidding Documents.

E. The Base Bid is the sum stated in the Bid for which the Bidder offers to perform the Work described in the Bidding Documents as the base, to which work may be added or from which work may be deleted for sums stated in Alternate Bids.

F. An Alternate Bid (or Alternate) is an amount stated in the Bid to be added to or deducted from the amount of the Base Bid of the corresponding change in the Work, as described in the Bidding Documents or in the proposed Contract Documents.

G. A Bidder is a person or entity who submits a Bid.

H. A Sub-Bidder or Sub-Contractor is a person or entity who submits a bid to a Bidder for materials or labor for a portion of the Work.

1.5. EXAMINATION OF SITE

A. Each Bidder shall examine the Site and satisfy itself as to the condition thereof. Contact the Owner project coordinator for access to the Site. Refer to the Project Directory.

B. Each Bidder, by making his Bid, represents that he has read and understands the Bidding Documents.

C. Each Bidder, by making his Bid, represents that he has visited the site performed investigations and verifications as he deems necessary, and familiarized himself with the local conditions under which the Work is to be performed and will be responsible for any and all errors in his proposal resulting from his failure to do so.

D. Each Bidder by making his Bid represents that his Bid is based upon the materials, systems and equipment required by the Bidding Documents without exception.

1.6. PREPARATION AND SUBMISSION OF PROPOSAL

A. Each Bidder shall fully complete and submit to Owner and Engineer one Proposal (the "Proposal") on the form included herein.

B. Each Proposal must be submitted in a sealed envelope bearing the name and address of the Bidder, and the name for which the Proposal is submitted. Each Proposal should be dated as of the Proposal Due Date.

C. If forwarded by mail, the sealed envelope containing the Proposal must be enclosed in another envelope addressed as indicated in the Instructions to Bidders.

D. Any Proposal, which is qualified or not fully responsive, may be rejected by Owner.

E. Each Proposal shall be accompanied by three (3) fully completed copies of the Agreement between Owner and Contractor ("Agreement") signed by the Bidder, dated as of the Proposal Due Date. Compensation; should be both spelled out in words and in figures and be the same amount as entered in the Proposal.

F. The Contract Sum amount shall exclude all alternates. Any accepted alternate will be covered by Change Order to the original Agreement.

G. In the event the Bidder is not successful in being awarded the Contract, the signed copies of the Contract Agreement will be returned to the Bidder.

1.7. BONDS

A. The successful Bidder may be required to furnish a performance bond in the full amount of the Contract Sum, and a labor and material payment bond in the full amount of the Construction Fee, and if Owner so elects, the Contract Sum shall be increased as provided in Paragraph D of the Proposal.

1.8. SUBCONTRACTORS

A. Each Bidder must submit with its Proposal the names of all Subcontractors it intends to use to complete the Work.

1.9. RIGHTS OF OWNER

A. Owner reserves the right to reject any or all Proposals and to waive irregularities in the bidding.

B. No Proposal may be withdrawn for a period of thirty (30) days subsequent to the Proposal Due Date without the consent of Owner.

C. To protect the interests of Owner and Contractor, Contractor is reminded that it shall not proceed with the Work unless Contractor has first secured Owner's written notice to proceed.

1.10. ADDITIONAL INFORMATION

A. No interpretation, explanation or clarifications of any Contract Document will be binding on Owner unless reduced to writing and signed by Owner.

1.11. STATE REGISTRATION

A. Each Bidder and its Subcontractors must be registered in the State in which the Site is located, if so required by legal requirements.

1.12. AWARD SCHEDULE

A. Owner intends to announce the selection of a Contractor and notify it to proceed with the Work within 10 days (10) days after the Proposal Due Date; however, if an award is not made within that time but within the 30-day period during which Proposals may not be withdrawn, then Contractor will be obligated to adhere to the construction progress schedule.

1.13. DOCUMENT PACKAGE

A. Upon receipt of the Contract Documents, each Bidder shall carefully review Exhibit "A" to the Agreement to determine that all the Contract Documents listed thereon have been included, and that none of the Contract Documents has been omitted. If any items or the Contract Documents have been omitted, the Bidder shall notify Owner to such effect. If Bidder shall fail to so notify Owner, the Bidder will be deemed to have received all Documents so listed.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – PRODUCTS (NOT USED)**

**END OF SECTION**

# SECTION 00200

# ADDITIONAL INFORMATION FOR BIDDERS

## PART 1 - GENERAL

1.1 SCOPE

A. The Work of this Contract shall consist of all labor, materials, tools, equipment and related items required for the complete electrical and general construction work for the Domestic Water System Replacement project at HCA Lee's Summit Medical Center located at 2100 SE Blue Pkwy, Lee's Summit, MO 64063.

1.2 SUBSTITUTIONS

A. The Engineer will not attempt to determine the acceptability of any product substitution during the Bid Period.

B. Substitutions proposed by a Bidder shall not be included in the Base Bid but may be appropriately itemized on the Bid Form with corresponding add or deduct amounts included.

1.3 QUALIFICATIONS OF BIDDERS

A. Bidding will be by invited Contractors.

B. In submitting a proposal, the Bidder thereby represents that he is fully qualified and properly licensed to perform the work in accordance with all applicable laws and ordinances.

1.4 COMMUNICATIONS

A. All communications shall be in writing, faxed or emailed, and directed to:

WSP
Attn: Mr. Ben Sitzia ben.sitzia@wsp.com
200 Wyandotte, Suite 200
Kansas City, Missouri 64105

B. Questions, clarifications and reports of discrepancies shall be made by Bidders only (the primary contractors). Calls, faxes and/or emails from sub-contractors or suppliers will not be taken or responded to unless pre-arranged.

1.5 ADDENDA

A. Answers to all questions, inquiries, and requests for additional information will be issued in the form of Addenda to the Contract Documents. A copy of each Addendum will be issued to all prospective bidders who have returned the Acknowledgement of Receipt.

B. Bidders may, during the time allowed for bidding, be advised by Addenda of

additions, deletions, or changes of the requirements of the Drawings and/or Specifications.

C. The Engineer and the Owner will not be responsible for the authenticity or correctness of oral interpretations or for information obtained in any other manner than through the medium of Addenda.

D. Receipt of each Addendum will be acknowledged in the bidder's proposal, and all Addenda will be made a part of the Contract Documents.

1.6 AVAILABILITY OF CONSTRUCTION DOCUMENTS FOR BIDDING

A. Each Bidder will be issued a set of reproducible drawings and specifications.

B. Expense of printing additional copies of drawings and specifications shall be the responsibility of the Bidder.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 00210

# GENERAL INFORMATION – PROJECT DIRECTORY

## PART 1 – GENERAL

1.1 OWNER

A. Hospital Corporation of America (HCA), 6100 Tower Circle, Suite 400, Franklin, TN 37067

B. OWNER'S PROJECT COORDINATOR

a. HCA
Mr. Adam Castro
Project Manager
2545 Park Plaza
Nashville, TN 37203
PHONE (615) 426-1565
Email: Adam.Castro@HealthTrustPG.com

C. OWNER'S ENGINEER/PROJECT MANAGER:
a. WSP
Attn: Mr. Ben Sitzia ben.sitzia@wsp.com
200 Wyandotte, Suite 200
Kansas City, Missouri 64105

1.2 PROJECT IDENTIFICATION: HCA Lee's Summit Medical Center Domestic Water System Replacement Project

1.3 PROJECT LOCATION: Lee's Summit, MO

## PART 2 – PRODUCTS (NOT USED)

## PART 3 – EXECUTION (NOT USED)

## END OF SECTION

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**SECTION 00410**

**BID FORM**

**PART 1 - GENERAL**

1.1 SUMMARY

A. PROPOSAL OF:
(Name and Address of Bidder)

B. BID DUE DATE: May 17, 2022

TO: WSP
Attn: Mr. Ben Sitzia benjamin.sitzia@wsp.com
200 Wyandotte, Suite 200
Kansas City, Missouri 64105

TO: HCA
Attn: Mr. Adam Castro
2545 Park Plaza
Nashville, TN 37203

1.1 RE: HCA Lee's Summit Medical Center
Domestic Water System Replacement Project

1.2 BIDDER

A. Bidder in response to Owner's invitation to bid and in accordance with the Instructions to Bidders hereby offers and proposes to perform the Work for the construction of the Project for the Contract Sum set forth below.

B. The undersigned, having examined the Specifications, Drawings and related documents, hereby propose to provide all products and installation and related requirements in strict conformity with the Specifications and Drawings prepared by WSP dated April 5, 2024

1.3 CONTRACT SUM:
(Price shall be in words and figures.)

_____Dollars ($ )

1.4 PERFORMANCE AND LABOR AND MATERIAL BONDS:
(Do not include amount in Contract Sum in paragraph C, above):

A. Furnish a performance bond in the full amount of the Contract Sum and a labor and material payment bond in the full amount of the Contract Sum.

B. The estimated cost of the bonds based on this Proposal is $
C. If the Owner elects to require these bonds, the actual premium cost of the bonds will

be added to the Contract Sum by Change Order.

D. If the Owner requires these bonds, no monies shall be expended by the Contractor for this Contract until the bonds have been received and approved by the Owner. In the event the bonds are not received within fourteen (14) days from the date of acceptance of the Contractor's Proposal and notification to obtain these bonds, Owner may, at its option, cancel this Contract and then the Contract shall then be of no further force and effect.

1.5 SUBCONTRACTORS

A. In submitting this Proposal it is the intention of the Bidder to use the following Subcontractors:

a. Subcontractor:

Work To Be Performed:

b. Subcontractor:

Work To Be Performed:

c. Subcontractor:

Work To Be Performed:

d. (Include additional subcontractors as required)

1.6 THE AGREEMENT

A. Any alterations or changes to the Agreement by the Bidder will be justification to disqualify the Bidder's Proposal.

B. In the event the Bidder's Proposal is not accepted by Owner, the signed copies of the Agreement will be returned to the Bidder.

1.7 RIGHTS OF OWNER

A. Bidder understands that Owner reserves the right to reject any or all Proposals and to waive irregularities in the bidding. Failure to complete all items on this Proposal form may be cause for rejection.

B. Bidder agrees that this Proposal may not be withdrawn for a period of thirty (30) calendar days from the Proposal Due Date.

C. Bidder understands that Owner shall have the right to terminate the Agreement in accordance with the General Conditions.

D. Bidder acknowledges that it shall not proceed with the Work unless Contractor has

first secured Owner's written notice to proceed.

1.8 COMPLETION DATES

A. The Project Schedule requires the following dates to be complied with:

a. Scheduled Substantial Completion Date: August 15, 2024

1.9 ADDENDA RECEIPT

A. The receipt of Addenda Nos. through to the Contract Documents is hereby acknowledged.

1.10 CONSTRUCTION COST BREAKDOWN

A. Instructions

a. The individual line items in the cost breakdown correspond to comparable Divisions of Sections of the Specifications. The dollar amount entered for any item shall represent the total cost of such item(s).
b. If any item is not sufficiently detailed, add additional subsections at the end thereof and unit prices for each item added.
c. Alternates shall be included under Alternate Proposals only, not in the cost breakdown.
d. If additional items (and sub-items) are required, add same at the end and set forth unit prices.
e. Cost estimate and breakdown amounts are to include installation cost for material and labor furnished.

| B. COST BREAKDOWNS | Manufacturer/Vendor | Cost |
|---|---|---|
| 1. Mechanical | _____ | _____ |
| 2. Electrical | _____ | _____ |
| SUBTOTAL | | _____ |
| TAXES | | _____ |
| CONTRACT SUM (GRAND TOTAL) | | _____ |

C. By submitting this Proposal, the Bidder acknowledges that it has carefully studied the Contract Documents and is familiar with the Site conditions and all Legal Requirements affecting the Work, as more particularly provided in the General Conditions of the Contract, and can complete the Work so as to comply with the dates set forth in Paragraph 1.9 above.

Dated this_____day of _____, 20__

Bidder

By:

Authorized Signature

Address of Bidder:

Bidder's Telephone No.:

State License No.

(SEAL)

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01010

# SPECIAL REQUIREMENTS

## PART 1 – GENERAL

1.1 PROJECT DESCRIPTION

A. HCA Lee's Summit Medical Center Domestic Water System Replacement Project

B. Refer to all applicable items in the Contract Documents

1.2 SCOPE

A. The following special requirements are intended to set forth requirements for the Project not specified elsewhere in the Contract Documents. Instructions contained herein do not invalidate any of the other requirements of in any other Contract Document.

B. General reference headings are used only as a matter of convenience and are not intended as a suggested or required subcontract responsibility.

1.3 ADJOINING BUILDING

A. Contractor shall be aware that the existing Hospital is an operating facility and shall adhere to the following requirements:

1. The Contractor shall coordinate his work with the HCA Lee's Summit Medical Center.

2. The Contractor shall notify the HCA Lee's Summit Medical Center of all construction procedures that might cause danger to the existing operations or personnel.

3. In order to minimize inconvenience and disturbance of the normal operation of the facility, it will be necessary for the Contractor to schedule and perform the work related to existing construction in an expeditious manner.

4. The Contractor shall take every precaution to ensure that the existing operating facility shall not at any time (except when approved by the HCA Lee's Summit Medical Center) remain exposed to the new construction. The Contractor shall erect and maintain suitable and effective dust proof partitions, screening, etc., (studs with plywood sheathing, etc.) at all areas or openings between the surrounding Tenant Spaces and the areas of work. The Contractor shall control his workmen's actions, noise, etc., to limit, as much as possible, disturbances to mall personnel and customers.

B. Contractor shall repair and restore any damage to the facility caused directly or indirectly as a result of the work within the building.

1.4 REPAIR AND RESTORATION

A. Prior to the commencement of Work "before" photographs shall be taken by the Contractor in the storage and staging areas and construction access routes at points designated by Owner's representative. These photographs will be compared against the conditions, which exist at the completion of the Work, by the Contractor and Owner's project manager. Any damage to the existing facilities caused by Contractor shall be repaired by the Contractor. Any surface, which has been impregnated, stained, or disfigured, will be considered damaged.

1.5 RELEASE OF LIEN

A. Use forms in specification section 01270 included herein unless otherwise mandated by state law.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01011

# REGULATORY REQUIREMENTS

## PART 1 – GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Sections, as applicable. Refer to other Divisions for coordination of work.

1.2 SUMMARY

A. The following listing of codes and regulatory agencies is a partial listing only and is not intended to be a complete list of all regulatory requirements, which apply to Project.

B. Inclusion of this Section is for Contractor's benefit to identify codes and regulations under which Contract Documents have been prepared. Contractor's attention is called to the required compliance with laws, statutes, building codes and regulations.

1.3 CODES

A. Building Code – IBC 2018 International Building Code.

B. Mechanical Code – IBC 2018 International Mechanical Code.

C. Plumbing Code –IPC 2018 International Plumbing Code.

D. Fire Code – IFC 2018 International Fire Code.

E. Energy Code – 2018 International Energy Conservation Code.

F. Electrical Code – 2017 National Electrical Code (NEC).

## PART 2 – PRODUCTS (NOT USED)

## PART 3 – EXECUTION (NOT USED)

## END OF SECTION

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# SECTION 01110

# SUMMARY OF WORK

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2 WORK COVERED BY CONTRACT DOCUMENTS

A. Work of this Contract comprises mechanical and electrical work associated with the Domestic Water System Replacement Project at HCA Lee's Summit Medical Center in Lee's Summit, MO.

1.3 CONTRACTOR'S DUTIES

A. Except as specifically noted, provide and pay for:

1. Labor, materials and equipment.

2. Tools, construction equipment and machinery.

3. Other facilities and services necessary for proper execution and completion of work.

B. Pay legally required sales, consumer and use taxes, which are legally enacted at time bids are received, whether or not yet effective.

C. Secure and pay for, as necessary for proper execution and completion of Work, and as applicable at time of receipt of bids:

1. Permits.

2. Government Fees (including inspection fees).

3. Licenses.

D. Give required notices.

E. Comply with codes, ordinances, rules, regulations, orders and other legal requirements of public authorities, which bear on performance of Work.

F. Promptly submit written notice to Engineer of observed variance of Contract Documents from legal requirements. Assume responsibility for Work known to be contrary to such requirements, without notice.

1.4 CONTRACT METHOD

A. Construct the Work under a single lump sum fixed price contract.

1.5 WORK SEQUENCE AND SPECIAL REQUIREMENTS

A. Contractor shall make each subcontractor engaged in work on the project aware that the present building houses an operating facility that must continue in operation during the construction period, except as the Owner and Engineer may otherwise direct. Plumbing, heating, ventilating, electrical, and telephone systems shall continue to function with a minimum of interruptions in service.

B. Construct Work in stages to accommodate Owner use of premises during construction. Coordinate Progress Schedule and coordinate with Owner Occupancy during construction.

C. Contractor shall assume responsibility for the protection of all areas of work and shall provide and maintain all protections required. Contractor shall protect existing surfaces of the building and equipment, both interior and exterior, as required during the construction period. Provide necessary dust screens, drop cloths, and temporary walls and/or coverings as may be required for protection. Existing surfaces that are damaged due to construction shall be patched or replaced to original condition.

D. Where designated on the plans, the Contractor shall salvage, relocate and reinstall certain items. Existing items so designated shall be properly installed, securely fastened as required, set plumb and level, and left complete and operational. Exercise extensive care in re-locating such items so as to prevent damage. All other existing building materials indicated to be removed or demolished, unless noted otherwise or claimed by the Owner shall become property of the Contractor and shall be removed from the site immediately.

1.6 CONTRACTOR USE OF PREMISES

A. Contractor shall limit use of premises for Work, for storage and for access, to allow for:

1. Owner occupancy.

2. Work by other contractors.

B. Coordinate use of premises under direction of Owner and Engineer.

C. Assume full responsibility for protection and safekeeping of products under this Contract.

D. Obtain and pay for use of additional storage or work areas needed when required for operations under this Contract.

1.7 OWNER OCCUPANCY

A. Owner will occupy premises during entire construction period for conduct of his normal operations. Cooperate with Owner in scheduling operations to minimize

conflict and to facilitate Owner usage.

**PART 2 - PRODUCTS - (NOT USED)**

**PART 3 - EXECUTION - (NOT USED)**

**END OF SECTION**

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# SECTION 01250

# CONTRACT MODIFICATION PROCEDURES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies administrative and procedural requirements for handling and processing Contract modifications.

B. Refer to Division 1 Section "Product Substitution Procedures" for administrative procedures for handling requests for substitutions made after Contract award.

1.2 MINOR CHANGES IN THE WORK

A. Engineer will issue supplemental instructions authorizing Minor Changes in the Work, not involving adjustment to the Contract Sum or the Contract Time.

1.3 PROPOSAL REQUESTS

A. Owner-Initiated Proposal Requests: Engineer will issue a detailed description of proposed changes in the Work that may require adjustment to the Contract Sum or the Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications.

1. Proposal Requests issued by Engineer are for information only. Do not consider them instructions either to stop work in progress or to execute the proposed change.

2. Within time specified in Proposal Request and after receipt of Proposal Request, submit a quotation estimating cost adjustments to the Contract Sum and the Contract Time necessary to execute the change.

a. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.

b. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.

c. Include an updated Contractor's Construction Schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.

B. Contractor-Initiated Proposals: If latent or unforeseen conditions require modifications to the Contract, Contractor may propose changes by submitting a request for a change to Engineer using Contractor's Standard Form.

1. Include a statement outlining reasons for the change and the effect of the change on the Work. Provide a complete description of the proposed change. Indicate the effect of the proposed change on the Contract Sum and the Contract Time.

2. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.

3. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.

4. Include an updated Contractor's Construction Schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.

5. Comply with requirements in Division 1 Section "Product Substitution Procedures" if the proposed change requires substitution of one product or system for product or system specified.

1.4 CHANGE ORDER PROCEDURES

A. On Owner's approval of a Proposal Request, Owner will issue a Change Order for signatures of Owner and Contractor.

1.5 CONSTRUCTION CHANGE DIRECTIVE

A. Construction Change Directive: Engineer may issue a Construction Change Directive. Construction Change Directive instructs Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order.

1. Construction Change Directive contains a complete description of change in the Work. It also designates method to be followed to determine change in the Contract Sum or the Contract Time.

B. Documentation: Maintain detailed records on a time and material basis of work required by the Construction Change Directive.

1. After completion of change, submit an itemized account and supporting data necessary to substantiate cost and time adjustments to the Contract.

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

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

**END OF SECTION**

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# SECTION 01290

# PAYMENT PROCEDURES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies administrative and procedural requirements necessary to prepare and process Applications for Payment.

1.2 SCHEDULE OF VALUES

A. Coordination: Coordinate preparation of the Schedule of Values with preparation of Contractor's Construction Schedule.

1. Correlate line items in the Schedule of Values with other required administrative forms and schedules, including the following:

a. Application for Payment forms with Continuation Sheets.

b. Submittals Schedule.

2. Submit the Schedule of Values to Engineer at earliest possible date but no later than seven days before the date scheduled for submittal of initial Applications for Payment.

3. Subschedules: Where the Work is separated into phases requiring separately phased payments, provide subschedules showing values correlated with each phase of payment.

B. Format and Content: Use the Project Manual table of contents as a guide to establish line items for the Schedule of Values. Provide at least one line item for each Specification Section.

1. Identification: Include the following Project identification on the Schedule of Values:

a. Project name and location.

b. Name of Engineer.

c. Engineer's project number.

d. Contractor's name and address.

e. Date of submittal.

2. Arrange the Schedule of Values in tabular form with separate columns to indicate the following for each item listed:

a. Related Specification Section or Division.

b. Description of the Work.

c. Name of subcontractor.

d. Name of manufacturer or fabricator.

e. Name of supplier.

f. Change Orders (numbers) that affect value.

g. Dollar value. Percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.

3. Provide a breakdown of the Contract Sum in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Coordinate with the Project Manual table of contents. Provide several line items for principal subcontract amounts, where appropriate.

4. Round amounts to nearest whole dollar; total shall equal the Contract Sum.

5. Provide a separate line item in the Schedule of Values for each part of the Work where Applications for Payment may include materials or equipment purchased or fabricated and stored, but not yet installed.

   a. Differentiate between items stored on-site and items stored off-site. Include evidence of insurance or bonded warehousing if required.

6. Provide separate line items in the Schedule of Values for initial cost of materials, for each subsequent stage of completion, and for total installed value of that part of the Work.

7. Each item in the Schedule of Values and Applications for Payment shall be complete. Include total cost and proportionate share of general overhead and profit for each item.

   a. Temporary facilities and other major cost items that are not direct cost of actual work-in-place may be shown either as separate line items in the Schedule of Values or distributed as general overhead expense, at Contractor's option.

8. Schedule Updating: Update and resubmit the Schedule of Values before the next Applications for Payment when Change Orders or Construction Change Directives result in a change in the Contract Sum.

1.3 APPLICATIONS FOR PAYMENT

A. Each Application for Payment shall be consistent with previous applications and payments as certified by and paid for by Owner.

1. Initial Application for Payment, Application for Payment at time of Substantial Completion, and final Application for Payment involve additional requirements.

B. Payment Application Times: The date for each progress payment is indicated in the Agreement between Owner and Contractor. The period of construction Work covered by each Application for Payment is the period indicated in the Agreement.

1. If the Agreement does not state payment dates, establish dates at preconstruction conference.

C. Payment Application Forms: Use AIA Document G702 and AIA Document G703 Continuation Sheets as form for Applications for Payment.

D. Application Preparation: Complete every entry on form. Notarize and execute by a person authorized to sign legal documents on behalf of Contractor. Architect will return incomplete applications without action.

1. Entries shall match data on the Schedule of Values and Contractor's Construction Schedule. Use updated schedules if revisions were made.

2. Include amounts of Change Orders and Construction Change Directives issued before last day of construction period covered by application.

E. Transmittal: Submit 3 signed and notarized original copies of each Application for Payment to Engineer by a method ensuring receipt within 24 hours. One copy shall include waivers of lien and similar attachments if required.

1. Transmit each copy with a transmittal form listing attachments and recording appropriate information about application.

F. Waivers of Mechanic's Lien: With each Application for Payment, submit waivers of mechanic's lien from every entity who is lawfully entitled to file a mechanic's lien arising out of the Contract and related to the Work covered by the payment.

1. Submit partial waivers on each item for amount requested, before deduction for retainage, on each item.

2. When an application shows completion of an item, submit final or full waivers.

3. Owner reserves the right to designate which entities involved in the Work must submit waivers.

4. Waiver Delays: Submit each Application for Payment with Contractor's waiver of mechanic's lien for construction period covered by the application.

    a. Submit final Application for Payment with or preceded by final waivers from every entity involved with performance of the Work covered by the application who is lawfully entitled to a lien.

5. Waiver Forms: Submit waivers of lien on forms, executed in a manner acceptable to Owner.

G. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:

1. List of subcontractors.

2. Schedule of Values.

3. Contractor's Construction Schedule (preliminary if not final).

4. Products list.

5. Schedule of unit prices.

6. Submittals Schedule (preliminary if not final).

7. List of Contractor's staff assignments.

8. List of Contractor's principal consultants.

9. Copies of building permits.

10. Copies of authorizations and licenses from authorities having jurisdiction for performance of the Work.

11. Initial progress report.

12. Report of preconstruction conference.

13. Certificates of insurance and insurance policies.

14. Performances and payment bonds.

H. Application for Payment at Substantial Completion: After issuing the Certificate of Substantial Completion, submit an Application for Payment showing 100 percent completion for portion of the Work claimed as substantially complete.

1. Include documentation supporting claim that the Work is substantially complete and a statement showing an accounting of changes to the Contract Sum.

2. This application shall reflect Certificates of Partial Substantial Completion issued previously for Owner occupancy of designated portions of the Work.

I. Final Payment Application: Submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited, to the following:

1. Evidence of completion of Project closeout requirements.

2. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.

3. Updated final statement, accounting for final changes to the Contract Sum.

4. AIA Document G706, "Contractor's Affidavit of Payment of Debts and Claims."

5. AIA Document G706A, "Contractor's Affidavit of Release of Liens."

6. AIA Document G707, "Consent of Surety to Final Payment."

7. Evidence that claims have been settled.

8. Final meter readings for utilities, a measured record of stored fuel, and similar data as of date of Substantial Completion or when Owner took possession of and assumed responsibility for corresponding elements of the Work.

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

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

**END OF SECTION**

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# SECTION 01310

# GENERAL PROJECT COORDINATION

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2 DESCRIPTION

A. Coordinate scheduling, submittals, and work of the various sections of Specifications to assure efficient and orderly sequence of installation of construction elements, with provisions for accommodating items to be installed later.

B. Coordinate sequence of Work to accommodate the scheduled completion date.

1.3 MEETINGS

A. In addition to construction progress meetings, hold coordination meetings and pre-installation conferences with personnel and subcontractors to assure coordination of Work.

1.4 COORDINATION OF SUBMITTALS

A. Schedule and coordinate submittals of shop drawings and product data.

B. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.

C. Coordinate requests for substitutions to assure compatibility of space, of operating elements, and affect on work of other sections.

1.5 COORDINATION OF SPACE

A. Coordinate use of Project space and sequence of installation of work, which is indicated diagrammatically on the Drawings. Follow routings where shown for conduits as closely as practicable, with due allowance for available physical space; make above ground conduit runs parallel with lines of building. Utilize space efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

1.6 COORDINATION OF CONTRACT CLOSEOUT

A. Coordinate completion and cleanup of work in preparation for Substantial Completion of Work. After Owner acceptance of work coordinate access to site by various sections for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's

activities.

B. Assemble and coordinate submittal of closeout documentation.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01311

# MECHANICAL AND ELECTRICAL COORDINATION

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the drawings are collectively applicable to this Section.

1.2 GENERAL REQUIREMENTS

A. Provide necessary work and services required for the complete installation of the mechanical and electrical equipment and systems as indicated on the Drawings.

B. Construct to comply with applicable codes, laws and The Americans with Disabilities Act when applicable. Where the requirements of the Contract Documents exceed code requirements, comply with the Contract Documents.

C. Perform electrical work in accordance with the City of Missouri adopted National Electric Code as a minimum standard of quality and safety.

1.3 COORDINATION

A. Coordinate the mechanical and electrical work with that of the other trades. Install the various components of the system at the proper time, fit the available space, and to allow proper service access to those requiring maintenance, including equipment specified in other divisions.

B. Provide materials with trim to match and fit properly with the types of adjacent ceiling, wall and floor finishes actually installed.

1.4 CONSTRUCTION DOCUMENTS

A. The Drawings diagrammatically indicate how the various components are integrated within the project. Determine exact locations by field measurement, by checking the requirements of the other trades and by review of the Contract Documents.

B. The Drawings indicate general routing of the various parts of the system, but may not indicate all the sizes, fittings, offsets, and runouts required. Provide correct sizes, fittings, offsets, and runouts required to fit the system into space allocated to them.

1.5 GENERAL REQUIREMENTS FOR ALL EQUIPMENT

A. Provide equipment with necessary parts and accessories.

B. Provide factory applied finish on all exterior surfaces. Touch up or refinish items,

which have the finish marred, before final acceptance.

C. Rotating parts shall be in static and dynamic balance.

D. Electrical material shall bear the stamp of approval of the Underwriters Laboratory.

1.6 NOISE

A. Eliminate any abnormal noises, which are not an inherent part of the systems as designed. Abnormal squeaks, buzzing and rattling of equipment and components will not be acceptable.

1.7 PROTECTION OF EQUIPMENT

A. Do not deliver equipment to job site until progress of construction has reached the stage where equipment is actually needed, unless space is allotted within the building for storage until equipment is needed.

B. Do not store equipment outdoors. Equipment allowed to stand outdoors in weather will be rejected, and new equipment of a like kind shall be furnished.

C. Adequately protect equipment from damage after delivery to the job site. Cover with heavy drop cloths as required to protect from physical damage.

D. Equipment, which has been damaged by construction activities, will be rejected, and new equipment of a like kind shall be furnished.

1.8 SUBMITTALS AND SHOP DRAWINGS

A. Furnish Submittals and Shop Drawings to conform to the requirements of these Specifications.

B. Equipment and material submittals shall show sufficient data to indicate complete compliance with the Contract Documents as follows:

1. Proper sizes and capabilities.

2. Ability to fit in the available space in a manner that will allow proper service.

3. Construction methods, material, and finishes.

4. List of accessories.

C. Product data shall include the contract items designation, building, and proposed model number.

D. For any item to be installed in or on a finished surface, certify that applicable Contract Documents have been checked and that the item submitted is compatible with the surface finish on which it is to be installed.

E. Coordination of all systems is the responsibility of the Prime Contractor.

1.9 MANUFACTURER'S DIRECTION AND SUPERVISION

A. Follow manufacturer's direction for installation, testing, and operation of all apparatus and equipment provided.

B. Where supervision by manufacturer is required in the Specifications, pay all costs and follow all instructions and recommendations of the manufacturer, who shall supervise the installation, connection, startup adjustment, instructions to the Owner, and final tests of equipment and systems. Where two or more manufacturer's equipment is interrelated, coordinate the work and the supervision.

1.10 TESTING

A. Provide testing as described in the various technical sections.

B. Complete testing reports shall be included in the Operations and Maintenance data required to be prepared by the Contractor.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

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# SECTION 01312

# FIELD ENGINEERING

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 SUMMARY

A. Provide and pay for field engineering services required for Project:

1. Professional engineering services specified or required to execute Contractor's construction methods.

1.3 QUALIFICATIONS OF ENGINEER

A. Registered professional engineer or discipline required for specific service on project. Licensed in the State of Missouri.

1.4 SUBMITTALS

A. Submit documentation to verify accuracy of field engineering work upon Engineer's request.

## PART 2 - PRODUCTS (NOT USED)

## PART 3 - EXECUTION (NOT USED)

## END OF SECTION

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# SECTION 01315

# PROJECT MEETINGS

## PART 1 - GENERAL

1.1 SUMMARY

A. Owner, Engineer, and Contractor shall schedule jointly for times to hold pre-construction meeting, progress meetings, and other required meetings.

B. Scheduler of meeting will:

1. Notify all involved parties at least four days in advance of each meeting.

2. Administer meetings.

3. Record significant proceedings and decisions at each meeting.

4. Reproduce and distribute copies of proceedings and decisions to parties in attendance and others affected by proceedings and decisions, within five days after meeting.

C. An Owner's Representative will attend all meetings requiring Owner's attendance. Meetings held without Owner may be required to be repeated if deemed necessary by Owner for Owner's needs.

1.2 PRE-CONSTRUCTION MEETING

A. Engineer will schedule pre-construction meeting within 15 days after date of execution of Contract or Notice to Proceed at project field office or other central site, convenient to all parties.

B. Attendance

1. Owner

2. Engineer

3. Contractor

4. Subcontractors

5. Contractor/Subcontractor safety representatives

6. Major suppliers as required.

7. Others as required.

C. Minimum Agenda

1. List of subcontractors.
2. Construction schedule.
3. Critical work sequencing.
4. Relation and coordination of various parties.
5. Designation of responsible personnel for each party.
6. Processing of:
    a. Requests for Information.
    b. Change Orders.
    c. Other modifications to Contract.
    d. Proposal Requests.
    e. Shop Drawings and Product Data.
    f. Applications for Payment.
7. Adequacy of distribution of Contract Documents.
8. Use of premises, including:
    a. Office and storage areas.
    b. Temporary facilities and controls, and security procedures.
    c. Owner's requirements.
9. Procedures for maintaining post-construction submittals
    a. Project Record Documents.
    b. Operation and Maintenance Data.
    c. Warranties.
10. Safety Procedures.

1.3 PROGRESS MEETINGS

A. Contractor shall schedule and administer weekly construction progress meetings and other called meetings or pre-installation meetings, throughout progress of Work.

B. Make physical arrangements, prepare agenda, and distribute notice of each

meeting to participants, and to Engineer five (5) business days in advance of meeting date.

C. Preside at meetings, record minutes, and distribute copies within two (2) business days after meeting to participants and to entities affected by decisions at meetings.

D. Location of Meetings: Contractor's field office. Attendance: Contractor, job superintendent, subcontractors, and suppliers as appropriate to agenda; Owner, Engineer and professional consultants may attend as appropriate.

C. Minimum Agenda

1. Review and approve minutes of previous meeting.

2. Review work progress since previous meeting, including:

a. Field observations, conflicts and problems, and decisions.

b. Problems, which impede planned progress.

c. Off-site fabrication schedules and potential problems.

d. Progress schedule and completion date.

3. Discuss and take corrective measures as appropriate to maintain quality standards, progress schedule and completion date.

4. Identify planned progress during next work period.

5. Review submittal and shop drawing log.

6. Review RFI, change order, and proposal request log.

7. Review injuries and accidents on project.

8. Effect of proposed changes on progress schedule and coordination.

9. Other business relating to Work.

1.4 PRE-INSTALLATION MEETINGS

A. When required in individual specification Sections, convene a pre-installation meeting at the work site prior to commencing work of the Section.

B. Require attendance of entities directly affecting, or affected by, work of the Section.

C. Notify Engineer five (5) days in advance of meeting date.

D. Prepare agenda, preside at conference, record minutes, and distribute copies within two (2) days after conference to participants, with two (2) copies to

Engineer.

E. Review conditions of installation, preparation and installation procedures, and coordination with related work.

**PART 2 - PRODUCTS (NOT APPLICABLE)**

**PART 3 - EXECUTION (NOT APPLICABLE)**

**END OF SECTION**

# SECTION 01320

# PROJECT SCHEDULES

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. FORMAT

A. Prepare Progress Schedules as a horizontal bar chart with separate bar for each major portion of Work or operation, identifying first workday of each week.

B. Sequence of Listings: The chronological order of the start of each item of Work.

C. Scale and Spacing: To provide space for notations and revisions.

D. Sheet Size: Maximum 11 x 17 inches.

1.3. CONTENT

A. Show complete sequence of construction by activity, with dates for beginning and completion of each element of construction.

B. Identify each item by major Specification section number.

C. Identify work of separate stages and other logically grouped activities.

D. Provide sub-schedules for each stage of Work.

E. Provide sub-schedules to define critical portions of entire Schedule.

F. Show accumulated percentage of completion of each item, and total percentage of Work completed, as of the first day of each month.

G. Provide separate schedule of submittal dates for shop drawings, product data, and samples, including Owner furnished products and dates reviewed submittals will be required from Engineer. Show decision dates for selection of finishes.

H. Show delivery dates for Owner furnished products.

I. Coordinate content with Schedule of Values.

1.4. REVISIONS TO SCHEDULES

A. Indicate progress of each activity to date of submittal, and projected completion date of each activity.

B. Identify activities modified since previous submittal, major changes in scope, and other identifiable changes.

C. Provide narrative report to define problem areas, anticipated delays, and impact on Schedule. Report corrective action taken, or proposed, and its effect, including the effect of changes on schedules of separate contractors.

1.5. SUBMITTALS

A. Submit initial Schedules within 10 days from Notice to Proceed. After review, resubmit required revised data within 5 days.

B. Submit revised Progress Schedules with each Application for Payment.

1.6. DISTRIBUTION

A. Distribute copies of reviewed Schedules to job site file, subcontractors, suppliers, and other concerned entities.

B. Instruct recipients to promptly report, in writing, problems anticipated by projections shown in Schedules.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01321

# PROJECT REPORTS

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 REQUIREMENTS INCLUDED

A. Each subcontractor shall maintain a comprehensive daily log of construction activities and compile daily logs into weekly progress report.

1.3 CONTENT OF REPORTS

A. Include the following for each workday:

1. Manpower by trade.

2. Work being performed and location thereof.

3. Situations or conditions, which could delay, work or give cause for claims, extensions of time, or added costs.

4. List of visitors including officials, Owner's representatives and other authorities.

5. Field decisions needed and actions taken.

1.4 SUBMITTAL

A. Submit copies of weekly reports and daily logs along with each Application for Payment; include construction photographs.

## PART 2 - PRODUCTS (NOT APPLICABLE)

## PART 3 - EXECUTION (NOT APPLICABLE)

## END OF SECTION

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# SECTION 01330

# SUBMITTAL PROCEDURES

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. SCOPE

A. The Engineer and Prime Contractor shall jointly be responsible for establishing and maintaining procedures for the preparation and processing of Shop Drawings and samples in accordance with the requirements set forth herein and the General Conditions.

B. Shop Drawings and samples shall be submitted for all materials and equipment where called for in the respective sections of the Contract Specifications.

C. The General Contractor shall keep and have available on the job one complete set of all approved Shop Drawings, cuts and samples.

1.3. SHOP DRAWINGS

A. Present in a clear and thorough manner original drawings, which illustrate the portion of the work showing fabrication, layout, setting, or erection details, prepared by a qualified detailer. Title each drawing with Project and Contract name and number; identify each element of drawings by reference to sheet number and detail, schedule, or room number of Contract Documents.

B. Identify field dimensions; show relation to adjacent or critical features of Work or products.

C. Individual Shop Drawings within a set shall be of uniform size, each with a title block and space for a review stamp in the lower right hand corner. Prints shall be sharp, clear and easily readable.

D. Contractor shall obtain approvals from required agencies prior to submitting Shop Drawings. All Shop Drawings, etc., which are to be reviewed by Owner are to be submitted to Owner only after being reviewed by the Contractor and Engineer.

1.4. PRODUCT DATA

A. Submit only pages, which are pertinent; mark each copy of standard printed data to identify pertinent products, referenced to Specification Section and Article number. Show reference standards, performance characteristics, and capacities; wiring and piping diagrams and controls; component parts; finishes;

dimensions; and required clearances.

B. Modify manufacturer's standard schematic drawings and diagrams to supplement standard information and to provide information specifically applicable to the Work. Delete information not applicable.

1.5. SAMPLES

A. All samples shall be large enough to clearly represent all physical characteristics, which have a bearing on the selections and appearance of the material.

1.6. CONTRACTOR REVIEW

A. Review submittals prior to transmittal; determine and verify field measurements, field construction criteria, quantities and details, manufacturer's catalog numbers, and conformance of submittal with requirements of Contract Documents. Correct any errors, omissions, or deviations prior to transmitting to Engineer.

B. Coordinate submittals with requirements of Work and of Contract Documents.

C. Sign or initial in a rubber-stamped review block format, each sheet of shop drawings and product data to certify compliance with requirements of Contract Documents. Notify Engineer in writing at time of submittal, of any deviations from requirements of Contract Documents.

D. Do not fabricate products or begin work, which requires submittals until return of submittal with Engineer's stamp and initials or signature indicating review.

E. Contractor's responsibility for errors and omissions in submittals is not relieved by Engineer's review of submittals.

F. Contractor's responsibility for deviations in submittals from requirements of Contract Documents is not relieved by Engineer's review of submittals, unless Engineer gives specific written acceptance of deviations. Engineer will review submittals for general conformance to design intent only.

1.7. SUBMITTAL REQUIREMENTS

A. Transmit submittals in accordance with approved Project Schedule, and in such sequence to avoid delay in the Work or work of other contracts.

B. Provide 8 x 4 inch blank space on each submittal for Contractor and Engineer stamps.

C. Apply Contractor's stamp, signed or initialed, certifying to review, verification of products, field dimensions and field construction criteria, and coordination of information with requirements of Work and Contract Documents.

D. Coordinate submittals into logical groupings to facilitate interrelation of the

several items:

1. Finishes which involve selection of colors, textures, or patterns.

2. Associated items, which require correlation for efficient function or for installation.

E. Submit one reproducible transparency and two (2) opaque copies of shop drawings.

F. Submit number of copies of product data and manufacturer's instructions Contractor requires, plus three (3) copies, which will be retained by Engineer.

G. Submit under Engineer accepted form transmittal letter. Identify project by title and number. Identify Work and product by Specification section and Article number.

H. All items shall be clearly identified with the manufacturer's name, item designation, project name and location.

I. Each submission shall clearly show the date of the original submission and of each subsequent revision or resubmission.

J. Unless specifically directed to the contrary, the submittal and resubmittal of Shop Drawings and related documents shall consist of one reproducible transparency (sepia) and one print or five (5) copies of related catalogs and catalog data for approval.

K. The Contractor shall submit to the Construction Manager a complete Shop Drawing schedule showing the sequence of submission dates and a schedule of dates for approval of all Shop Drawings.

1.8. SUBMITTAL CLASSIFICATION AND PROCEDURES:

A. REVIEW STAMP: Each office reviewing Shop Drawings shall so indicate directly on the drawings by affixing a stamp which will contain among other items the name of the reviewing party, the date and outcome of the review and required further action. Any submittals not bearing such stamp shall not be considered.

B. SUBMITTALS MARKED "NO EXCEPTIONS TAKEN" - are submittals, which require no corrections by the Engineer/Architect.

C. SUBMITTALS MARKED "MAKE CORRECTIONS NOTED" - are submittals, which require minor corrections as noted. This stamp shall mean that the checking is complete and fabrication may proceed, provided all corrections noted are adhered to. If fabrication or installation is not in strict accordance with the corrections noted, the work shall be rejected and all corrections shall be made at no cost to the Owner.

D. SUBMITTALS MARKED "REVISE & RESUBMIT" - are submittals in which items,

as noted, shall be further clarified before acceptance can be given. Fabrication may not proceed on those items marked.

E. SUBMITTALS MARKED "REJECTED" - are submittals, which are not in accordance with the PHD criteria and/or the Contract Documents. No work may proceed under this mark. These submittals must be corrected and resubmitted for approval.

1.9. RESUBMITTALS

A. Make resubmittals under procedures specified for initial submittals; identify changes made since previous submittal.

B. Corrected drawings resubmitted for review and approval shall have no changes other than those called for in the review notes on the previous submission. If additional changes or revisions are made they shall be clearly indicated on the drawings and fully explained in writing with the submission.

1.10. ENGINEER AND CONSULTANT REVIEW

A. Engineer and consultants will review shop drawings and product data and return submittals generally within 14 days.

1.11. DISTRIBUTION

A. Duplicate and distribute reproductions of shop drawings and copies of product data, which bear Engineer stamp of approval, to job site file, Record Documents file, subcontractors, suppliers, and other entities requiring information.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01450

# CONTRACT QUALITY CONTROL

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. DESCRIPTION

A. Maintain quality control over supervision, subcontractors, suppliers, manufacturers, products, services, workmanship, and site conditions, to produce Work in accordance with Contract Documents.

1.3. WORKMANSHIP

A. Comply with industry standards of the region except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.

B. Provide suitably qualified personnel to produce Work of specified quality.

C. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking.

1.4. MANUFACTURER'S INSTRUCTIONS

A. Require compliance with instructions in full detail, including each step in sequence.

B. Should instruction conflict with Contract Documents, request clarification from Engineer before proceeding.

1.5. MANUFACTURER'S CERTIFICATES

A. When required in individual Specifications sections, submit manufacturer's certificate, in duplicate, certifying that products meet or exceed specified requirements, executed by responsible officer.

1.6. MANUFACTURER'S FIELD SERVICES

A. When required in individual Specifications sections, have manufacturer (or his authorized representative) provide qualified representative to observe field conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment test, adjust, and balance of equipment as applicable, and to make written report of observations and recommendations to Engineer.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01500

# CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. FACILITIES

A. Space is available within the hospital for minimal lockboxes and hand tools. Any additional materials or work space will require a trailer (not supplied by owner).

1.3. WATER

A. Provide service required for construction operations. Extend branch piping with outlets located so that water is available by use of hoses.

B. It is acceptable to connect to existing facilities; extend branch piping with outlets located so that water is available by use of hoses.

1.4. BARRIERS

A. Provide as required to prevent public entry to construction areas to provide for Owner's use of site, and to protect existing facilities and adjacent properties from damage from construction operations.

B. Provide temporary barriers and ventilation in accordance with the Hospital Infection Control Procedures.

1.5. PROTECTION OF INSTALLED WORK

A. Provide temporary protection for installed products. Control traffic in immediate area to minimize damage.

1.6. PARKING

A. Coordinate allowable parking areas with Owner.

B. When site space is not adequate, provide additional off-site parking.

1.7. CLEANING DURING CONSTRUCTION

A. Control accumulation of waste materials and rubbish; periodically dispose of off-site.

B. Clean interior areas prior to start of finish work, maintain areas free of dust and

other contaminants during finishing operations.

1.8. REMOVAL

A. Remove temporary materials, equipment, services, and construction prior to Substantial Completion inspection.

B. Clean and repair damage caused by installation or use of temporary facilities. Restore existing facilities used during construction to specified, or to original, condition.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION**

3.1 GENERAL

A. Comply with applicable requirements specified in Division 23 (Mechanical).

B. Maintain and operate systems to assure continuous service.

C. Modify and extend systems, as work progress requires.

**END OF SECTION**

# SECTION 01600

# PRODUCT REQUIREMENTS

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 SUMMARY

A. Material and equipment incorporated into work.

1. Conform to applicable specifications and standards.

2. Comply with size, make, type and quality specified, or as specifically approved in writing by Engineer.

3. Manufactured and Fabricated Products.

a. Design, fabricate and assemble in accordance with best engineering and shop practices.

b. Manufacture like parts or duplicate units to standard sizes and gages, to be interchangeable.

c. Two or more items of same kind shall be identical, by same manufacturer.

d. Products shall be suitable for service conditions.

e. Equipment capacities, sizes and dimensions shown or specified shall be adhered to unless variations are specifically approved in writing.

4. Do not use material or equipment for any purpose other than that for which it is designed or is specified.

1.3 MANUFACTURER'S INSTRUCTIONS

A. When Contract Documents require that installation of work shall comply with manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in installation, including three (3) copies to Engineer.

B. Maintain one set of complete instructions at job site during installation and until completion.

C. Handle, install, connect, clean, condition, and adjust products in strict accordance with such instructions and in conformance with specified requirements.

1. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with Engineer for further instructions.

2. Do not proceed with work without clear instructions.

D. Perform work in accordance with manufacturer's instructions. Do not omit any preparatory step or installation procedure unless specifically modified or exempted by Contract Documents.

1.4 TRANSPORTATION AND HANDLING

A. Arrange deliveries of products in accordance with construction schedules; coordinate to avoid conflict with work and conditions at site.

1. Deliver products in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.

2. Immediately upon delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals, and that products are properly protected and undamaged.

B. Provide equipment and personnel to handle products by methods to prevent soiling or damage to products or packaging.

1.5 STORAGE AND PROTECTION

A. Store products on site unless prior written approval has been obtained from Owner.

B. Store products in accordance with manufacturer's instructions, with seals and labels intact and legible.

1. Store products subject to damage by elements in weathertight enclosures.

2. Maintain temperature and humidity within ranges required by manufacturer's instructions.

C. Exterior Storage

1. Store fabricated products above ground, on blocking or skids; prevent soiling or staining. Cover products, which are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.

2. Store loose granular materials in well-drained area on sheet of plastic on solid surfaces to prevent mixing with foreign matter.

D. Arrange storage in manner or provide easy access for inspection. Make periodic inspections of stored products to assure that products are maintained under specified conditions, and free from damage or deterioration.

E. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.

F. Maintain manufacturer's product data sheets at all times for hazardous materials used or stored on job site.

1.6 REUSE OF EXISTING MATERIAL

A. Except as specifically indicated or specified, materials and equipment removed from existing structure shall not be used in completed work.

B. For material and equipment specifically indicated or specified to be reused in work.

1. Use special care in removal, handling, storage and reinstallation to assure proper function in completed work.

2. Arrange for transportation, storage and handling of products, which require off-site storage, restoration or renovation. Pay all costs for such work.

**PART 2 - PRODUCTS (NOT APPLICABLE)**

**PART 3 - EXECUTION (NOT APPLICABLE)**

**END OF SECTION**

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# SECTION 01610

# TRANSPORTATION AND HANDLING

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

## PART 2 - PRODUCTS (NOT USED)

## PART 3 - EXECUTION

3.1 PACKAGING, TRANSPORTATION

1. Require supplier to package products in boxes or crates for protection during shipment, handling, and storage. Protect sensitive products against exposure to elements and moisture.

2. Protect sensitive equipment and finishes against impact, abrasion, and other damage.

3.2 DELIVERY AND RECEIVING

1. Arrange deliveries of products in accordance with construction progress schedules. Allow time for inspection prior to installation.

2. Coordinate deliveries to avoid conflict with Work and conditions at site; work of other contractors or Owner; limitations on storage space; availability of personnel and handling equipment; and Owner's use of premises.

3. Deliver products in undamaged, dry condition, in original unopened containers or packaging with identifying labels intact and legible.

4. Clearly mark partial deliveries of component parts of equipment to identify equipment and contents to permit easy accumulation of parts and to facilitate assembly.

5. Immediately on delivery, inspect shipment to assure:

    1. Product complies with requirements of Contract Documents and reviewed submittals.

    2. Quantities are correct.

    3. Accessories and installation hardware are correct.

    4. Containers and packages are intact and labels legible.

5. Products are protected and undamaged.

3.3 PRODUCT HANDLING

1. Provide equipment and personnel to handle products, including those provided by Owner, by methods to prevent soiling and damage.

2. Provide additional protection during handling to prevent marring and otherwise damaging products, packaging, and surrounding surfaces.

3. Handle product by methods to avoid bending or overstressing. Lift large and heavy components only at designated lift points.

**END OF SECTION**

# SECTION 01620

# STORAGE AND PROTECTION

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

## PART 2 - PRODUCTS (NOT USED)

## PART 3 - EXECUTION

3.1 STORAGE, GENERAL

A. Store products, immediately on delivery, in accordance with manufacturer's instructions, with seals and labels intact. Protect until installed.

B. Arrange storage in a manner to provide access for maintenance of stored items and for inspection.

3.2 ENCLOSED STORAGE

A. Maintain temperature and humidity within ranges stated in manufacturer's instructions.

B. Provide humidity control and ventilation for sensitive products as required by manufacturer's instructions.

C. Store unpacked and loose products on shelves, in bins, or in neat groups of like items.

3.3 MAINTENANCE OF STORAGE

A. Periodically inspect stored products on a scheduled basis.

B. Verify that storage facilities comply with manufacturer's product storage requirements.

C. Verify that manufacturer required environmental conditions are maintained continually.

3.4 MAINTENANCE OF EQUIPMENT STORAGE

A. For electrical equipment in long-term storage, provide manufacturer's service instructions to accompany each item, with notice of enclosed instructions shown on exterior of package.

B. Service equipment on a regularly scheduled basis, maintaining a log of services; submit as a record document.

**END OF SECTION**

# SECTION 01630

# PRODUCT SUBSTITUTION PROCEDURES

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. OPTIONS

A. Products Specified by Reference Standards or by Description Only: Any product meeting those standards.

B. Products Specified by Naming One or More Manufacturers with a Provision for Substitutions: Submit a request for substitution for any manufacturer, not specifically named, within time frame specified herein.

C. Products Specified by Naming Several Manufacturers: Products of named manufacturers meeting specifications; no options, no substitutions.

D. Products Specified by Naming Only One Manufacturer: No option; no substitution.

1.3. PRODUCTS LIST

A. Within ten (10) days after date of Notice to Proceed, transmit three (3) copies of a list of major products, which are proposed for installation, including name of manufacturer.

B. Tabulate products by Specifications section number, title, and paragraph or article number.

C. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

D. Engineer will reply in writing within ten (10) days stating whether there is reasonable objection to listed items. Failure to object to a listed item shall not constitute a waiver of requirements of Contract Documents.

1.4. LIMITATIONS ON SUBSTITUTIONS

A. Requests for substitutions of products will be considered only within ten (10) days after date established in Notice to Proceed. Subsequent requests will be considered only in case of product unavailability or other conditions beyond control of Contractor.

B. Substitutions will not be considered when indicated on shop drawings or product data submittals without separate formal request, when requested directly by

subcontractor or supplier, or when acceptance will require substantial revision of Contract Documents.

C. Substitute products shall not be ordered or installed without written acceptance.

D. Only one request for substitution for each product will be considered. When substitution is not accepted, provide specified product.

E. Engineer will determine acceptability of substitutions.

1.5. REQUESTS FOR SUBSTITUTIONS

A. Submit separate request for each substitution. Document each request with complete data substantiating compliance of proposed substitution with requirements of Contract Documents. Utilize substitution request form attached.

B. Identify product by Specifications section and Article numbers. Provide manufacturer's name and address, trade name of product, and model or catalog number. List fabricators and suppliers as appropriate.

C. Attach product data as specified in Section 01330.

D. List similar projects using product, dates of installation, and names of Engineer and Owner.

E. Give itemized comparison of proposed substitution with specified product, listing variations, and reference to Specifications section and Article numbers.

F. Give quality and performance comparison between proposed substitution and the specified product.

G. Give cost data comparing proposed substitution with specified product, and amount of net change to Contract Sum.

H. List availability of maintenance services and replacement materials.

I. State effect of substitution on construction schedule, and changes required in other work or products.

1.6. CONTRACTOR REPRESENTATION

A. Request for substitution constitutes a representation that Contractor has investigated proposed product and has determined that it is equal to or superior in all respects to specified product or that the cost reduction offered (if any) is ample justification for accepting the offered substitution.

B. Contractor will provide same warranty for substitution as for specified product.

C. Contractor will coordinate installation of accepted substitute, making such changes as may be required for Work to be complete in all respects.

D. Contractor certifies that cost data presented is complete and includes all related costs under this Contract.

E. Contractor waives claims for additional costs related to substitution, which may later become apparent.

1.7. SUBMITTAL PROCEDURES

A. Submit three (3) copies of request for substitution.

B. Engineer will review Contractor's requests for substitutions with reasonable promptness.

C. During the bidding period, Engineer will record acceptable substitutions in Addenda.

D. After award of Contract, Engineer will notify Contractor, in writing, of decision to accept or reject requested substitution, generally within ten (10) days.

E. For accepted products, submit shop drawings, product data, and samples under provisions of Section 01330.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**SUBSTITUTION REQUEST FORM**

DATE: _____

PROJECT: Lee's Summit Medical Center
Domestic Water System Replacement

FROM: _____

_____

Contractor (Bidder) hereby requests acceptance of the following product or system as substitution in accordance with provisions of Section 01630 of the Specifications:

1. SPECIFIED PRODUCT OR SYSTEM:

   Substitution Request For: _____

   Specification Section No.: _____

2. SUPPORTING DATA:

   _____Substitution Request Form is attached with descriptive information of product including reference standards, performance and test data, specifications, drawings, and photographs, as required to describe the substitute product as completely as possible.

   _____Sample is attached.

   _____Sample will be sent if requested.

3. QUALITY COMPARISON

| SPECIFIED PRODUCT | SUBSTITUTION |
|---|---|
| Name: | Name: |
| Manufacturer: | Manufacturer: |
| Catalog No.: | Catalog No.: |
| Vendor: | Vendor: |

Significant Variations from Specified Product:

_____

_____

_____

Maintenance Service Available: Yes No

Spare Parts Source: _____

Warranty Provided: Yes No Years _____

By Whom: _____

4. PREVIOUS INSTALLATIONS:

Identification of similar projects on which proposed substitution was used:

Project: _____ Engineer: _____

Address: _____ Owner: _____

Date Installed: _____

5. REASON FOR NOT GIVING PRIORITY TO SPECIFIED ITEMS:

A. AFFECT OF SUBSTITUTION:

Substitution affects other work (adverse or otherwise):

No Yes (if yes, explain; attach additional information if necessary)

_____

_____

_____

Substitution changes contract time: No Yes

Add/Deduct _____Days

Substitution requires dimensional revisions or redesign of the work: No Yes

(if yes, attach detailed explanation)

Saving or Credit to Owner: $ _____

Extra Cost to Owner: $ _____

B. CONTRACTOR'S (BIDDER'S) STATEMENT OF CONFORMANCE OF PROPOSED SUBSTITUTION TO CONTRACT DOCUMENTS:

I/we have investigated the proposed substitution including function, appearance and quality to specified product, except as stated above; as specified for specified product; the substitution; special inspection costs caused by the use of this product; substitution in the work; by the substitution.

Contractor (Bidder):_____

Date: _____By:_____

Answer all questions and complete all blanks - use "NA" if not applicable. Unresponsive or incomplete request will be rejected.

==========

ENGINEER'S REVIEW AND ACTION

_____ Resubmit substitution request.

_____ Provide more information in the following areas:

_____

_____

_____ Sign Contractor's (Bidder's) Statement of Conformance.

_____ No exception taken to substitution.

_____ No exception taken to substitution, with the following comments:

_____

_____

_____ Substitution rejected.

_____ Substitution request received too late.

_____Date: _____
Engineer

**END OF SECTION**

# SECTION 01640

# REQUEST FOR INFORMATION

## PART 1 – GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SECTION INCLUDES

A. Administrative and procedural requirements for handling and processing Requests for Information (RFI).

1.3. DEFINITIONS:

A. Requests for Information: A formal process used during construction to facilitate communication between Contractor, HCA, and Engineer with regard to requests for additional information and clarification of the intent of the Contract Documents (Drawings and Specifications).

1.4. PROCEDURE

A. Do not use Request for Information format during Bidding. For questions during bidding, refer to Instructions to Bidders.

B. Conditions Requiring Clarification of Contract Documents: Submit Request for Information to HCA Construction Manager and Engineer.

1. Submit Requests for Information from Contractor's office or field office only. Requests submitted directly from subcontractors or suppliers are not permitted.

2. Generate Requests for Information by one source per project and number accordingly.

C. HCA and Engineer will review formal requests from Contractor with reasonable promptness and Contractor will be notified in writing of decisions made.

1. HCA and Engineer response shall not be considered as a Change Order or Change Directive, nor does it authorize changes in the Contract Sum or Contract Time.

D. Maintain log of Requests for Information sent to, and responses from HCA and Engineer.

E. Scheduling, Costing, and Owner Provided Equipment Coordination: Direct to the HCA Construction Manager.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01720

# PROJECT RECORD DOCUMENTS

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2 MAINTENANCE OF DOCUMENTS AND SAMPLES

A. In addition to requirements in General Conditions, maintain at the site for Owner one record copy of:

1. Contract Drawings.

2. Specifications.

3. Addenda.

4. Change Orders and other modifications to the Contract.

5. Reviewed shop drawings, product data, and samples.

6. Field test records.

7. Inspection certificates.

8. Manufacturer's certificates.

B. Store Record Documents and samples in Field Office apart from documents used for construction. Provide files, racks, and secure storage for Record Documents and samples.

C. Label and file Record Documents and samples in accordance with Section number listings in Table of Contents of this Project Manual. Label each document "PROJECT RECORD" in neat, large, printed letters.

D. Maintain Record Documents in a clean, dry and legible condition. Do not use Record Documents for construction purposes.

E. Keep Record Documents and samples available for review by Engineer.

1.3 RECORDING

A. Record information on a set of drawings, and in a copy of a Project Manual.

B. Provide felt tip marking pens, maintaining separate colors for each major

system, for recording information.

C. Record information concurrently with construction progress. Do not conceal any work until required information is recorded.

D. Contract Drawings and Shop Drawings: Legibly mark each item to record actual construction, including:

1. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.

2. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of construction.

3. Field changes of dimension and detail.

4. Changes made by Modifications.

5. Details not on original Contract Drawings.

6. References to related shop drawings and Modifications.

E. Specifications: Legibly mark each item to record actual construction, including:

1. Manufacturer, trade name, and catalog number of each product actually installed, particularly optional items and substitute items.

2. Changes made by Addenda and Modifications.

F. Other Documents: Maintain manufacturer's certifications, inspection certifications, field test records, and other documents required by individual Specifications sections.

G. Final Record Drawings:

1. Prepare final Record Drawings using computerized drafting software compatible with AutoDesk's AutoCAD®. Drawings files must be composite with multiple distinctive layers for each of the various trades.

2. Submit three sets of hardcopy of Record Drawings. Hardcopies of Record Drawings shall have each sheet clearly labeled with a unique sheet identification number.

3. In addition to hardcopies, submit one copy of Record Drawings in electronic format on CD or DVD. Files contained on disc shall be named to correspond with the sheet names contained in the hardcopy set. Files on disc shall include both AutoCAD® compatible source files and files printed to Portable Document Format (.pdf).

4. Record Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/8-inch equals one foot.

1.4 SUBMITTALS

A. At Contract closeout, deliver Record Documents and samples under provisions of Section 01770.

B. Transmit with cover letter in duplicate, listing:

1. Date.

2. Project title and number.

3. Contractor's name, address, and telephone number.

4. Number and title of each Record Document.

5. Signature of Contractor or authorized representative.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

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# SECTION 01730

# OPERATION AND MAINTENANCE DATA

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2 QUALITY ASSURANCE

A. Prepare instructions and data by personnel experienced in maintenance and operation of described products.

1.3 FORMAT

A. Prepare data in the form of an instructional manual.

B. Binders: Commercial quality, 8-1/2 x 11 inch three-ring binders with hardback, cleanable, plastic covers; three inch maximum ring size. When multiple binders are used, correlate data into related consistent groupings.

C. Cover: Identify each binder with typed or printed title OPERATION AND MAINTENANCE INSTRUCTIONS; list title of Project identify subject matter of contents.

D. Arrange content by systems, under section numbers and sequence of Table of Contents of this Project Manual.

E. Provide tabbed flyleaf for each separate product and system, with typed description of product and major component parts of equipment.

F. Text: Manufacturer's printed data, or typewritten data on 20 pound paper.

G. Drawings: Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.

1.4 CONTENTS, EACH VOLUME

A. Table of Contents: Provide title of Project; names, addresses, and telephone numbers of Engineer and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.

B. For Each Product or System: List names, addresses and telephone numbers of subcontractors and suppliers, including local source of supplies and replacement parts.

C. Product Data: Mark each sheet to clearly identify specific products and

component parts, and data applicable to installation; delete inapplicable information.

D. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems, to show control and flow diagrams. Do not use Project Record Documents as maintenance drawings.

E. Typed Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified in Section 01405.

F. Warranties and Bonds: Bind in copy of each.

1.5 MANUAL FOR EQUIPMENT AND SYSTEMS

A. Each Item of Equipment and Each System: Include description of unit or system, and component parts. Give function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.

B. Include as-installed color coded wiring diagrams.

C. Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences. Include regulation, control, stopping, shutdown, and emergency instructions. Include summer, winter, and any special operating instructions.

D. Maintenance Requirements: Include routine procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.

E. Provide servicing and lubrication schedule, and list of lubricants required.

F. Include manufacturer's printed operation and maintenance instructions.

G. Include sequence of operation by controls manufacturer.

H. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.

I. Provide as-installed control diagrams by controls manufacturer.

J. Provide Contractor's coordination drawings, with as-installed color coded piping diagrams.

K. Provide charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.

L. Provide list of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.

M. Additional Requirements: As specified in individual Specifications sections.

N. Provide a listing in Table of Contents for design data, with tabbed flysheet and space for insertion of data.

1.6 INSTRUCTION OF OWNER PERSONNEL

A. Before final inspection, instruct Owner's designated personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon times. For equipment requiring seasonal operation, perform instructions for other seasons within six months.

B. Use operation and maintenance manuals as basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

C. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

1.7 SUBMITTALS

A. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. Engineer will review draft and return one copy with comments.

B. For equipment, or component parts of equipment put into service during construction and operated by Owner, submit documents within ten days after acceptance.

C. Submit one copy of completed volumes in final form ten (10) days prior to final inspection. Copy will be returned after final inspection, with Engineer comments. Revise content of documents as required prior to final submittal.

D. Submit two copies of revised volumes of data in final form within ten (10) days after final inspection.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

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# SECTION 01735

# INSTRUCTION OF OWNER'S OPERATING AND MAINTENANCE PERSONNEL

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 DESCRIPTION

A. Instruct Owner's personnel in operation and maintenance of equipment and systems.

1.3 SUBMITTALS

A. Submit preliminary copy of "Instruction of Owner's Operating and Maintenance Personnel" report for each system or item requiring instruction, on photocopy of form provided herein, at least two (2) weeks prior to instruction date.

B. Submit two (2) fully completed forms upon completion of all instructions.

1.4 QUALITY ASSURANCE

A. Instruction shall be done by personnel:

1. Trained and experienced in maintenance and operation of described products.

2. Familiar with requirements of this Section.

1.5 SCHEDULING

A. Do not perform instruction until systems and equipment have been placed into operation.

B. Complete all instruction prior to Final Completion.

## PART 2 - PRODUCTS

2.1 MATERIALS

A. Use Operation and Maintenance Data specified in Section 01730 as basis for instruction.

B. Furnish specialized tools required to operate and maintain systems and equipment for Owner's use.

## PART 3 - EXECUTION

3.1 INSTRUCTION OF OWNER'S PERSONNEL

A. Instruct Owner's designated personnel in operation and maintenance of systems and equipment.

B. Provide level of instruction commensurate with system or item requiring instruction. Some items may require multiple training sessions at different times due to Owner's time of day operation.

C. Explain contents and use of Operation and Maintenance Data.

D. Explain operating sequences

1. Show location and operation of switches, valves and other such devices used to start, stop and adjust system.

2. Explain use of flow diagrams, operating sequence diagrams and other such devices.

3. Demonstrate operation through complete cycles and full range of operation through all modes, including testing and adjusting relevant to operation.

E. Explain use of control equipment, including device settings, switch modes, available adjustments, reading of gauges, and functions that must be serviced by factory authorized representatives.

F. Explain troubleshooting procedures

1. Demonstrate commonly occurring problems

2. Note procedures which must be performed by factory authorized personnel.

G. Explain maintenance procedures and requirements

1. Items requiring periodic maintenance.

2. Demonstrate preventative maintenance procedures and recommended maintenance intervals.

3. Demonstrate other commonly occurring maintenance procedures not part of periodic maintenance program.

4. Identify maintenance materials to be used.

**INSTRUCTION OF OWNER'S OPERATING PERSONNEL**

PROJECT: HCA – Lee's Summit Medical Center

SYSTEM OR EQUIPMENT: Domestic Water System Replacement

PRELIMINARY INFORMATION:

A. To be Completed by Contractor

1. Proposed dates of instruction:

   to _____.

2. Representative performing instruction:

3. Number of hours required:

B. To be Completed by Owner

1. Owner's personnel to be instructed:

**INSTRUCTION LOG**

PROJECT: HCA – Lee's Summit Medical Center

SYSTEM OR EQUIPMENT: Domestic Water System Replacement

DATE OF INSTRUCTION COMPLETED:

TOTAL HOURS COMPLETED:

COMMENTS:

Owner's Representative:

Instructor:

**END OF SECTION**

# SECTION 01740

# WARRANTIES AND BONDS

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. FORM OF SUBMITTALS

A. Bind in commercial quality 8-1/2 x 11 inch three-ring binders, with hardback, cleanable, plastic covers.

B. Label cover of each binder with typed or printed title WARRANTIES AND BONDS, with title of Project; name, address and telephone number of Contractor; and name of responsible principal.

C. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Project Manual, with each item identified with the number and title of the specification section in which specified, and the name of Product or work item.

D. Separate each warranty or bond with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.

1.3. PREPARATION OF SUBMITTALS

A. Obtain warranties and bonds, executed in duplicate by responsible subcontractors, suppliers, and manufacturers, within ten days after completion of the applicable item of work. Except for items put into use with Owner's permission, leave date of beginning of time of warranty until the Date of Substantial completion is determined.

B. Verify that documents are in proper form, contain full information, and are notarized.

C. Co-execute submittals when required.

D. Retain warranties and bonds until time specified for submittal.

1.4. TIME OF SUBMITTALS

A. For equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within ten days after acceptance.

B. Make other submittals within ten days after Date of Substantial Completion, prior

to final Application for Payment.

C. For items of Work when acceptance is delayed beyond Date of Substantial Completion, submit within ten days after acceptance, listing the date of acceptance as the beginning of the warranty period.

**PART 2 - PRODUCTS (NOT USED)**

**PART 3 - EXECUTION (NOT USED)**

**END OF SECTION**

# SECTION 01745

# SPARE PARTS, OVERAGES AND MAINTENANCE MATERIALS

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2 PRODUCTS REQUIRED

1. Provide quantities of products, spare parts, maintenance tools, and maintenance materials specified in individual sections to be provided to Owner, in addition to that required for completion of Work.

2. Products: Identical to those installed in the Work. Include quantities in original purchase from manufacturer to avoid variations in manufacture.

1.3 STORAGE, MAINTENANCE

1. Store products with products to be installed in the Work, under provisions of Section 01620.

2. After delivery of products to site, maintain spare products in same space and condition as products to be installed in the Work.

3. When adequate, secure storage facilities are available at site, capable of maintaining conditions required for storage and not required for Contract work or storage, or for Owner's needs, spare products may be stored in available space. This type of storage shall be coordinated directly with the Owner.

4. Maintain spare products in original containers with labels intact and legible, until delivery to Owner.

1.4 DELIVERY

1. Coordinate with Owner: Deliver and unload spare products to Owner at Project site and obtain receipt prior to final payment.

## PART 2 - PRODUCTS (NOT USED)

## PART 3 - EXECUTION (NOT USED)

## END OF SECTION

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# SECTION 01750

# INSPECTIONS AND TESTING

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 SUMMARY

A. Notify Owner and Engineer when work is ready for the following reviews:

1. Observation of equipment for general conformance to Drawings.

2. Rough-ins for mechanical and electrical.

3. Observation of installation of equipment.

4. Inspections required by local, State, and Federal authorities having jurisdiction over the project.

B. Testing:

1. Submit list of items requiring testing to the Engineer:

a. Item to be tested.

b. Who is responsible for establishing testing procedure?

c. Who will perform testing?

d. Results needed.

e. Who should attend test.

2. Owner and Engineer will review list and comment if appropriate. Additional tests may be added.

3. Notify Owner and Engineer at least 72 hours prior to each test. Retest at no additional cost to Owner if notification is not received and Owner and Engineer do not attend test.

4. Perform test in accordance with established testing procedures.

5. Submit retesting procedures for items failing initial tests. Retest at no additional cost to Owner.

C. Correct defective work and work failing tests at no additional cost to Owner.

**PART 2 - PRODUCTS (NOT APPLICABLE)**

**PART 3 - EXECUTION (NOT APPLICABLE)**

**END OF SECTION**

# SECTION 01770

# CLOSEOUT PROCEDURES

## PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. The General Conditions of the Contract, supplements thereto, Division 1 Specification Sections, and all other relevant documents issued as part of the Project, apply to work covered by this Section.

B. Comply with other Division 1 Section, as applicable. Refer to other Divisions for coordination of work.

1.2 SUMMARY

A. This Section specifies administrative and procedural requirements for project closeout, including but not limited to:

1. Inspection procedures.

B. Closeout requirements for specific construction activities are included in the appropriate Sections in Division 23 and Division 26.

1.3 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for certification of Substantial Completion, complete the following. List exceptions in the request.

1. In the Application for Payment that coincides with, or first follows, the date Substantial Completion is claimed, show 100 percent completion for the portion of the work claimed and substantially complete. Include supporting documentation for completion as indicated in these Contract Documents and a statement showing an accounting of changes to the Contract Sum.

a. If 100 percent completion cannot be shown, include a list of incomplete items, the value of incomplete construction, and reasons the work is not complete.

2. Advise Owner of pending insurance changeover requirements.

3. Submit specific warranties, workmanship bonds, maintenance agreements, final certifications and similar documents.

4. Obtain and submit releases enabling the Owner unrestricted use of the Work and access to services and utilities; include operating certificates and similar releases.

5. Submit record drawing, maintenance manuals, and similar final record information.

6. Deliver tools, spare parts, extra stock, and similar items.

7. Complete start-up testing of systems, and instruction of the Owner's operating and maintenance personnel. Discontinue or change over and remove temporary facilities from the site, along with construction tools, mock-ups and similar elements.

8. Complete final clean up requirements, including touch-up painting. Touch-up and otherwise repair and restore marred exposed finishes.

B. Requests:

1. When Contractor considers Work or designated portion of Work is substantially complete, submit written notice with list of items to be completed or corrected.

2. Should Engineer inspection find Work is not substantially complete, he will promptly notify Contractor in writing, listing observed deficiencies.

3. Contractor shall remedy deficiencies and send a second written notice of substantial completion.

4. When Engineer finds Work is substantially complete he will prepare a Certificate of Substantial Completion in accordance with provisions of General Conditions.

1.4 FINAL COMPLETION

A. When Contractor considers Work is complete, submit written certification:

1. Contract Documents have been reviewed.

2. Work has been inspected for compliance with Contract Documents.

3. Work has been completed in accordance with Contract Documents, and deficiencies listed with Certificate of Substantial Completion have been corrected.

4. Equipment and systems have been tested, adjusted and balanced, and are fully operational.

5. Operation of systems has been demonstrated to Owner's personnel.

6. Work is complete and ready for final inspection.

B. Should Engineer find Work incomplete, he will promptly notify Contractor in writing listing observed deficiencies.

C. Contractor shall remedy deficiencies and send a second certification of final

completion.

D. When Engineer finds work is complete, he will consider closeout submittals.

1.5 REINSPECTION FEES

A. Should status of completion of Work require reinspection by Engineer due to failure of Work to comply with Contractor's claims on initial inspection, Owner will deduct the amount of Engineer and appropriate consultants compensation for reinspection services from final payment to Contractor.

1.6 CLOSEOUT SUBMITTALS

A. Evidence of Compliance with Requirements of Governing Authorities:

1. Certificates of Inspection required for electrical systems.

B. Project Record Documents: Under provisions of Section 01720.

C. Operation and Maintenance Data: Under provisions of Section 01730.

D. Warranties and Bonds: Under provisions of Section 01740.

E. Spare Parts and Maintenance Materials: Under provisions of Section 01750.

F. Evidence of Payment and Release of Liens: In accordance with Conditions of the Contract.

G. Consent of Surety to Final Payment.

H. Certificates of Insurance for Products and Completed Operations: In accordance with Supplementary Conditions.

1.7 STATEMENT OF ADJUSTMENT OF ACCOUNTS

A. Submit final statement reflecting adjustments to Contract Sum indicating:

1. Original Contract Sum.

2. Previous change orders.

3. Deductions for uncorrected work.

4. Penalties and bonuses.

5. Deductions for liquidated damages.

6. Deductions for reinspection fees.

7. Other adjustments to Contract Sum.

8. Total Contract Sum as adjusted.

9. Previous payments.

10. Sum remaining due.

B. Owner will issue a final Change Order reflecting approved adjustments to Contract Sum not previously made by change orders.

1.8 APPLICATION FOR FINAL PAYMENT

A. Submit application for final payment in accordance with provisions of Conditions of the Contract.

**PART 2 - PRODUCTS (NOT APPLICABLE)**

**PART 3 - EXECUTION (NOT APPLICABLE)**

**END OF SECTION**

# SECTION 01771

# FINAL CLEANING

## PART 1 - GENERAL

1.1. RELATED DOCUMENTS

A. Provisions established within the Conditions of the Contract, Division 1 - General Requirements, and the Drawings are collectively applicable to this Section.

1.2. DESCRIPTION

A. Execute cleaning prior to review for Substantial Completion of the Work.

## PART 2 - PRODUCTS

2.1 CLEANING MATERIALS

A. Use materials which will not create hazards to health or property, and which will not damage surfaces.

B. Use only materials and methods recommended by manufacturer of material being cleaned.

## PART 3 - EXECUTION

3.1 CLEANING

A. In addition to removal of debris and cleaning specified in other sections, clean interior and exterior exposed-to-view surfaces.

B. Remove temporary protection and labels not required to remain.

C. Clean finishes free of dust, stains, films and other foreign substances.

D. Clean surfaces of equipment; remove excess lubrication.

E. Maintain cleaning until Final Completion.

F. Remove waste, debris, and surplus materials from site. Clean grounds; remove stains, spills, and foreign substances from paved areas and sweep clean.

**END OF SECTION**

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# SECTION 01 91 13

# GENERAL COMMISSIONING REQUIRMENTS

## PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning is a systematic process of ensuring the HVAC systems perform interactively according to the design intent and Owner's operational needs. Commissioning will encompass and coordinate traditionally separate functions of system documentation, installation checkout, equipment startup, control system calibration and point-to-point checkout, testing and balancing, and functional performance testing. Commissioning is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify systems are in accordance with the plans and specifications.

2. Verify and document proper installation and performance of equipment and systems.

3. Ensure O&M, maintenance training, and commissioning documentation requirements are complete.

4. Provide Owner with functional buildings and/or systems with minimal operational problems at time of move-in.

B. Commissioning does not take away from or reduce responsibility of system designers or installing contractors to provide a finished and fully functioning product.

C. This section shall in no way diminish the responsibility of the Division 23 Sub-contractors and Suppliers in performing all aspects of work and testing as outlined in the contract documents. Any requirements outlined in this section are in addition to requirements outlined in Division 23 Specifications.

1.2 ABBREVIATIONS

A. The following are common abbreviations used in the Specifications. Definitions are found further in this Section.

| Abbreviation | Full Name | Additional Information |
|---|---|---|
| A/E | Architect and Design | The HVAC Engineer |
| BAS | Building Automation System | |
| CA | Commissioning Agent | An employee or agent of the |
| CM | Construction Manager | HCA Construction Manager |
| CT | Commissioning Team | |

| Abbreviation | Full Name | Additional Information |
|---|---|---|
| Cx | Commissioning | |
| CC | Controls Contractor | |
| DFM | HCA Director of Facility Management | |
| EC | Electrical Contractor | |
| FPT | Functional Performance Test | |
| GC | General Contractor | |
| MC | Mechanical Contractor | |
| OR | Owner's Representative | |
| PC | Pre-functional Checklist | |
| TAB | Test, Adjust and Balance | |
| O&M | Operations & Maintenance | |
| RFI | Request for Information | |

1.3 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. The following sections apply to work specified in this section.

1. Section 23 08 00 - Commissioning

1.4 COORDINATION

A. Commissioning Team: Members of the Commissioning Team (CT) will consist of:

1. Commissioning Agent (CA)

2. Owner's Representative(s) (OR)

3. Construction Manager (CM)

4. Architect and Design Engineers (A/E)

5. Mechanical Contractor (MC)

6. Electrical Contractor (EC)

7. Test and Balance Contractor (TAB Contractor)

8. Controls Contractor (CC)

9. Equipment Suppliers and Vendors

B. Management: The CA directs and coordinates commissioning activities. All members of the Commissioning Team shall cooperate to fulfill contracted responsibilities and objectives of the Contract Documents.

C. Kick-off Meeting: Within 90 days of commencement of construction, CA and OR will plan, schedule and conduct a commissioning kick-off meeting. Membership and responsibilities of the commissioning team will be clarified at this meeting. CA will distribute meeting minutes to all parties.

D. Scheduling:

1. CA and OR will work with commissioning team to establish required commissioning activities to incorporate in preliminary commissioning schedule. The CA and GC will integrate commissioning activities into the master construction schedule. Representatives of the commissioning team will address scheduling problems. Necessary notifications are to be made in a timely manner in order to expedite commissioning.

2. The CA and OR will provide initial schedule of primary commissioning events at commissioning kick-off meeting. As construction progresses, more detailed schedules are developed by the CA.

1.5 DEFINITIONS

A. Acceptance Phase: Phase of construction after startup and initial checkout when Functional Performance Tests, O&M documentation review and training occur.

B. Approval: Acceptance that a piece of equipment or system has been properly installed and is functioning in tested modes according to the Contract Documents.

C. Architect/Engineer (A/E): Prime consultant (architect) and sub-consultants who comprise the design team, generally HVAC Mechanical Designer/Engineer and Electrical Designer/Engineer.

D. Commissioning Agent (CA): An assigned employee or agent of the GC. CA directs and coordinates day-to-day commissioning activities.

E. Contract Documents: Documents binding on parties involved in construction of this project (drawings, specifications, change orders, amendments, contracts, etc.).

F. Control System: System and components associated with building automation system.

G. Construction Manager (CM): Owner's employee assigned the responsibility of managing the overall project.

H. Deferred Functional Tests: Functional tests performed after substantial completion due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow test from being performed.

I. Deficiency: Condition of a component, piece of equipment or system that is not in compliance with Contract Documents (that is, does not perform properly or is not complying with design intent).

J. Director of Facility Management (DFM): Facility employee responsible for the maintenance of the Physical Plant.

K. Factory Testing: Testing of equipment on-site or at factory, by factory personnel.

L. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions that fully describe the steps required to determine if the system is performing and functioning properly. These procedures are written by the A/E and shall be used to document Functional Performance Tests. They shall be included in the Project Manual.

M. Functional Performance Test (FPT): A demonstration of the dynamic function and operation of equipment and systems. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with contract documents. The test results are both manually recorded on the FPT Procedure and with trending data using the BAS. Functional Performance Tests are executed after pre-functional checklists and startups are complete.

N. General Contractor: Contracted directly to Owner. Sub-contractors report to the General Contractor.

O. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

P. Manual Test: Using hand-held instruments, immediate control system readouts, or direct observation to verify performance (contrary to analyzing monitored data taken over time to make "observation").

Q. Monitoring: Recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or trending capabilities of control systems.

R. Non-Compliance: See Deficiency.

S. Non-Conformance: See Deficiency.

T. Overridden Value: Writing over a sensor value in the control system to see response of a system (e.g., changing outside air temperature value from 50°F to 75°F to verify economizer operation). See also "Simulated Signal".

U. Owner's Representative (OR) – An employee of the Owner or person contracted with the Owner to provide Cx Verification Services. The responsibility of the OR is to assist the Cx Team in understanding the Cx requirements of the project, monitor the Cx progress through site visits and Cx Team Meetings, review the completed Cx Pre-Functional Performance Checklists and Functional Performance Test for completeness, perform Cx verification testing as appropriate to determine that the Cx requirements of the project have been successfully completed.

V. Owner Verification: A repeat of the FPTs in the presence of the OR and A/E. The OR will determine if only selected or all FPTs will be repeated based on his inspection and review of the Cx documentation submitted by the CA prior to this visit. Typically the length of this visit is less than 3 days. On phased projects, phased commissioning may be required.

W. Phased Commissioning: Commissioning completed in phases (by floors, for example) due to size of structure or other scheduling issues.

X. Pre-functional Checklist (PC): 1) A list of static inspections and elementary component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). 2) Pre-functional Checklists may also include startup tests that prepare equipment and system for functional operation. 3) A summary of specified documentation is presented in checklist format. The A/E shall include the PCs in the Project manual.

Y. Seasonal Performance Tests: Functional Performance Tests or parts thereof that are deferred until system(s) ambient conditions are closer to design conditions in order to verify proper system operation.

Z. Simulated Condition: Condition created for testing component or system (e.g., applying heat to space temperature sensor to monitor response of VAV box).

AA. Simulated Signal: Disconnecting a sensor and using a signal generator or a software value to simulate an input value to the BAS.

BB. Specifications: Construction specifications of Contract Documents.

CC. Startup: The activities where systems or equipment are initially tested and operated. Startup is completed prior to functional testing.

DD. Sub-contractor: Contractors of GC, and their sub-contractors, who provide and install building components and systems.

EE. Test Procedures: Step-by-step processes, which must be executed to fulfill test requirements.

FF. Test Requirements: Requirements specifying what modes and functions, etc. will be tested.

GG. Trending: Recording of parameters (flow, temperature, pressure, status, etc.) during system operation using the BAS.

HH. Vendor: Supplier of equipment.

II. Warranty Period: Warranty period for entire project, including equipment components.

1.6 SUBMITTALS

A. CA shall provide the OR and A/E an "as-built" controls submittal 5 working days prior to the scheduled Owner's Verification visit. The submittal shall include the full sequences of operation that describe the actual controls programming.

1.7 START-UP

A. Sub-contractor responsible for purchase, installation and startup of equipment shall perform the manufacturer's detailed startup and checkout procedures in addition to the PCs.

B. GC/Sub-contractor shall compile documentation and recording forms for all testing and start-up required by Division 22, 23, and 26 specifications (e.g. duct pressure testing, duct cleaning, pipe pressure testing, piping flushing and cleaning plans, electrical testing, etc.). Testing documentation shall include:

1. Completed test forms

2. Completed Start-up forms

3. Equipment Maintenance Log

## PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division sub-contractors shall provide all specialized tools, test equipment and instruments required to execute startup, checkout and functional performance testing of equipment under their contract.

B. Test equipment shall be of sufficient quality and accuracy to test and/or measure system performance with tolerances specified. A testing laboratory shall have calibrated test equipment within the previous 12 months. Calibration shall be NIST traceable. Equipment shall be calibrated according to manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

## PART 3 - EXECUTION

3.1 COMMISSIONING OVERVIEW. The following provides a brief overview of typical commissioning tasks during construction and the general order in which they occur:

A. Commissioning during construction begins with a kick-off meeting conducted by CA and OR where membership of commissioning team is established, responsibilities reviewed, and the Cx scope and procedures are reviewed. A preliminary commissioning schedule is distributed for review.

B. CA schedules subsequent meetings as necessary to plan, coordinate and schedule commissioning activities. Deficiencies and problem resolution will also be discussed at these meetings.

C. CA develops, with cooperation of sub-contractor/vendor, detailed training plan. The CA schedules training activities with the facility's staff.

D. CA supervises the execution of the PCs completed by the subcontractors. PCs shall be completed for a piece of equipment prior to scheduling startup.

E. CA will witness startup of selected equipment. Startup Reports will be kept in the Start-Up Binder for review.

F. Sub-contractors complete testing (e.g. duct and piping pressure testing, piping flushing, etc.) as required by Division 1, 22, and 23 specifications. Sub-contractors compile copies of completed testing documentation in the Start-Up Binder for CA and OR review.

G. Sub-contractors perform start-up and initial checkout Sub-contractors assemble completed Start-Up Plan documentation and submit to CA for verification of completion of start-up activities prior to functional performance tests.

H. CA assembles the Cx team for a step by step review of the FPT procedures in advance of the execution of the first FPT. The A/E shall lead this review and immediately update any FPT that requires changes.

I. Functional testing is completed after TAB is completed.

J. A/E shall be present to assist in the execution of the first FPT. The CA shall coordinate the schedule for this test to coincide with the A/E's scheduled trip to attend an Owner-Architect-Contractor meeting.

K. Functional Performance Tests are executed by sub-contractors, under supervision of and documented by CA.

L. CA is responsible for having the completed FPT procedures, the specified trending data, the final T&B report, and the "as-built" control submittal to the OR and A/E not less than 5 working days prior to the scheduled Owner's Verification visit.

M. All the FPTs must be completed and the Owner's Verification must occur prior to occupancy unless otherwise directed by the CM. (Owner Verification may be waived on some phases of a phased project; however, the FPTs and controls submittal must be submitted to the OR prior to occupancy.)

N. Items of non-compliance in material, installation or setup will be corrected at sub-contractor expense and system shall be retested.

3.2 SYSTEMS TO BE COMMISSIONED

A. Mechanical:

1. Chillers, chilled water pumps, condenser water pumps, cooling tower performance per cell, two cells in the project, ancillary hydronic equipment and controls such as chilled water bypass valve, new 2-way control valves on existing air handler and fan coil equipment, refrigerant purge exhaust fans and controls.

2. Integration of new mechanical equipment into the existing Building Automation System

B. Electrical: Emergency Generator

3.3 RESPONSIBILITIES. The responsibilities of commissioning team members are:

A. Architect/Engineer (A/E):

1. Develop detailed PCs.

2. Develop detailed project specific FPT procedures.

3. Review FPTs in detail with the Cx Team.

4. Witnesses first run of first FPT.

5. Review all Cx documentation, including TAB reports, and provide written comments to the OR and CA within 5 days of receipt.

B. Commissioning Agent (CA):

1. Coordinate and direct commissioning activities in a logical, sequential and efficient manner.

2. Schedule and chair Cx kick-off meeting and issue minutes.

3. Incorporate commissioning activities into master construction schedule.

4. Schedule and chair all commissioning team meetings and issue minutes.

5. Provide progress reports of commissioning status.

6. Periodically update commissioning schedule.

7. Supervise completion of Pre-functional Checklists and supporting documentation to verify systems readiness for Functional Performance Testing.

8. Supervise Functional Performance Tests. Document test results and recommend system for acceptance.

9. Review completed TAB reports.

10. Develop, with cooperation of sub-contractor/vendor and DFM, a detailed training plan.

11. Schedule and oversee training sessions.

12. Prepare final Commissioning Turnover Documentation.

13. Facilitate cooperation of sub-contractors in commissioning work.

14. Forward completed TAB report, as-built controls submittal, FPT procedure, and trend data to OR and A/E and at least 5 working days prior to scheduled Owner Verification visit.

15. Identify, track and coordinate resolution of non-compliance and deficiencies identified by commissioning team. Maintain records of all issues submitted by commissioning team.

16. Coordinate sub-contractor/vendor participation in training sessions. Provide workspace or conference room as needed. Ensure attendance at training is documented.

17. Schedule, coordinate and assist CT in seasonal or deferred testing.

C. Sub-contractors/Vendors:

1. Review PCs and Functional Performance Test procedures.

2. Attend commissioning kick-off meeting and other commissioning team meetings.

3. Ensure installation work is complete, is in compliance with Contract Documents and is ready for Functional Performance Testing.

4. Execute Pre-functional Checklists and submit in electronic format with supporting documentation to CA and OR prior to startup of equipment.

5. Execute all required equipment and systems testing as required by project specifications (e.g. duct pressure testing, piping pressure testing, piping flushing, etc.). Provide schedule of testing activities to CA prior to start of any testing so that CA may witness a sampling of the testing as required. Submit completed testing documentation in final executed Start-Up binder to CA and OR for review prior to start of functional testing.

6. Execute all periodic maintenance required on started equipment from initial start-up of equipment to final acceptance by Owner to prevent equipment warranties from being voided. Document execution of periodic maintenance by signing and dating maintenance logs for each item of equipment.

7. Execute Functional Performance Tests as described in contract documents.

8. Provide certified and calibrated instrumentation required to take measurements of system and equipment performance during Functional Performance Testing.

9. Assist CA with developing a comprehensive commissioning schedule.

10. Execute seasonal or deferred Functional Performance Testing.

11. Make necessary amendments to O&M manuals and as-built drawings/submittals for applicable issues identified in the Cx process.

12. Support the testing that occurs during the Owner's Verification visits.

D. Controls Contractor (CC):

1. Attend commissioning kick-off meeting and other commissioning team meetings.

2. Completely install and thoroughly inspect startup, test, adjust, calibrate and document systems and equipment under BAS Contract.

3. Provide laptop computer, software and training to accommodate TAB Contractor in system balancing.

4. Maintain database of control parameters submitted by TAB Contractor subsequent to field adjustments and measurements.

5. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Functional Performance Testing and Owner's Verification.

6. Provide instrumentation, computer, software and communication resources necessary to demonstrate total operation of building systems during Functional Performance Testing and Owner's Verification of control system equipment.

7. Maintain comprehensive system calibration and checkout records. Submit records to CA upon request.

8. Submit executed copies of the commissioning functional tests (signed and dated by the control Sub-contractor technician directly responsible for verification of the control sequence or system operation) prior to Owner's Verification (to show that the control Sub-contractor has actually tested and verified each sequence prior to CA witnessing the functional testing).

9. Setup trend logs as requested by CA to substantiate proper systems operation.

10. Prepare the required trending information and submit to the CA.

11. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Opposed Season Functional Performance Testing.

E. Test, Adjust and Balance (TAB) Contractor:

1. Attend commissioning kick-off meeting and other commissioning team meetings.

2. Complete test and balance procedures prior to functional performance testing.

3. Cooperate with CC with execution of required work.

4. Submit copy of final TAB report to CA for review prior to Owner's verification visit.

5. Rebalance deficient areas identified during commissioning.

6. Provide on-site technician, as necessary, skilled in TAB procedures to provide limited system TAB readings during Functional Performance Testing and Owner's Verification.

7. Provide on-site technician skilled in software programming and hardware operation to exercise sequences of operation and to correct control deficiencies identified during Opposed Season Functional Performance Testing.

3.4 COMMISSIONING TEAM MEETINGS

A. Commissioning team meetings will be held periodically as determined by CA and OR with frequency increasing as construction advances and systems become operational. Attendance is mandatory. CA will record minutes and attendance. CA will chair Commissioning Team Meetings.

B. Discussions held in Commissioning Team Meetings shall include, but not be limited to system/equipment startup, progress, scheduling, testing, documentation, deficiencies and problem resolution.

3.5 REPORTING

A. CA will at OAC meetings provide regular status reports to CM and A/E.

B. CA will regularly communicate with members of commissioning team, keeping them apprised of commissioning progress.

C. CA shall submit non-compliance and deficiency reports to the CM.

3.6 PRE-FUNCTIONAL CHECKLISTS

A. The objective of the Pre-Functional Checklist is to verify and document that the equipment/systems are provided and installed according to documented design intent and Contract Documents.

B. Pre-functional checklists are provided by the A/E and executed as the work is completed in phases by the installing Sub-contractors. The project specific Pre-functional checklists are included at the end of this section by the A/E. GC and Sub-contractors shall review final construction documentation for applicable details and specifications related to equipment to be commissioned in order to fully ascertain all of the pre-functional checklist requirements.

C. The contractors will execute the pre-functional checklists in phases as work is completed such as setting equipment, piping equipment, insulating it, making up electrical connections, etc. The purpose is to execute the commissioning process and complete the checklists as the work is being completed and not to wait until the end of the installation to complete the checklists.

D. The Mechanical Contractor's field foreman shall inspect each piece of installed HVAC equipment using the appropriate Pre-functional Checklist. He shall initial and date each item when it passes inspection and re-inspect until all items pass.

E. When all items have successfully passed inspection the Mechanical Contractor's superintendent and the General Contractor's project manager shall separately inspect, sign and date the checklists to verify that the installation is complete.

F. The GC will maintain a single "master" hard copy of the PFC checklists executed by the Sub-contractors on-site for CT review during periodic site visits.

3.7 STARTUP AND INITIAL CHECKOUT

A. CA shall schedule equipment startup after the PCs are executed and documented by Sub-contractor. Startup shall not occur until after the CA and sub-contractors have reviewed the completed PCs.

B. Sub-contractor to prepare an overall schedule of testing and start-up activities in advance and forward to OR so that OR can witness start-up activities as required

C. OR reserves the right to witness any startup or equipment testing. DFM shall be contacted and invited to witness all equipment startup.

D. CA shall provide OR with signed and dated copy of completed startup and pre-functional checklists. Only individuals having direct knowledge that a line item task was actually performed will initial or check that item off.

E. CA shall clearly list outstanding items or initial startup and pre-functional procedures not completed successfully.

F. CA shall review deficiency reports to determine if outstanding items prevent scheduling of Functional Performance Testing.

3.8 FUNCTIONAL PERFORMANCE TESTING

A. Objectives and Scope:

1. The objective of Functional Performance Testing is to demonstrate each system is operating according to documented design intent and Contract Documents. Functional Performance Testing facilitates bringing systems from a state of substantial completion to full dynamic operation. Additionally, during Functional Performance Testing, areas of deficient performance are identified and corrected, improving operation and functioning of systems.

2. Each system shall be operated through all modes of operation where there is a specified system response. Verifying each sequence in the sequences of operation is required.

B. Development of Test Procedures:

1. The purpose of any given specific test is to verify and document compliance with stated criteria of acceptance given on test form. A/E shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CA will review the FPT procedures with the A/E and Cx Team (i.e. answering questions about equipment, operation, sequences, etc.). CA shall provide a copy of test procedures to Sub-contractor. Sub-contractor will review tests for feasibility, safety and equipment warranty protection. CA shall also submit tests to Owner, CM and A/E and other commissioning team members for review.

2. Examples of test procedure forms to be developed by the A/E are included herein.

C. Coordination and Scheduling:

1. CA will conduct a step by step table top review of the FPT procedures with the CT weeks in advance of the first FPT.

2. CA shall witness and document functional testing of equipment and systems. Sub-contractor shall execute tests under direction of CA.

3. Functional Performance Testing is conducted after system operation and checkout is satisfactorily completed. Air balancing and water balancing is to be completed and debugged before functional testing of air-related or water-related equipment or systems.

4. CA will schedule Owner's Verification visit with the OR and A/E after completion of functional performance test procedures by the CA.

5. CA will transmit the completed FPT procedures, associated trend data, TAB report, and "as-built" control submittal to the OR and A/E on a schedule that will give them five working days to review this information prior to the scheduled Owner's Verification visit.

3.9 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Documentation: CA will witness and document the results of the FPTs using specific Functional Performance Test procedures developed for that purpose. CA will include filled out FPTs in Commissioning Turnover Package.

B. Non-Conformance:

1. CA will record results of functional performance testing. Deficiency or non-conformance issues will be noted and reported to A/E and OR on notes section of the FPT procedure.

2. Corrections of minor deficiencies identified may be made during tests at discretion of CA. In such cases, deficiency and resolution will be documented on FPT form.

3. Every effort will be made to expedite testing and minimize unnecessary delays, while not compromising integrity of tests. CA shall not overlook deficient work or loosen acceptance criteria to satisfy scheduling or cost issues unless directed to do so by the OR.

4. Deficiencies are handled in the following manner:

a. When there is no dispute on deficiency and Sub-contractor accepts responsibility for remedial action:

1) CA documents deficiency.

2) CA reschedules test with Sub-contractor.

b. When there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

1) CA documents deficiency and the sub-contractor's response and they go on to another test or sequence.

2) CA facilitates resolution of deficiency. Other parties are brought into discussions as needed. Final interpretive authority is with A/E. Final acceptance authority is with the OR.

3) CA documents the resolution.

C. Approval:

1. CA notes each satisfactorily demonstrated function on test form. CA, A/E and OR provide formal approval of FPT. CA recommends acceptance of each test to A/E and OR. The OR maintains a Cx Issues Log that documents the issues/problems that arise during Cx Verification. The OR and A/E work together to update the log until all the issues are resolved to the satisfaction of the OR. The OR notifies the CM when the Cx Issues are resolved to the extent that occupancy by the Owner can occur.

3.10 COMMISSIONING DOCUMENTATION

A. Commissioning Turnover Package

1. CA is responsible to compile and organize commissioning records. CA shall deliver Cx records to the OR in Commissioning Binders. Turnover Package to include the following:

a. "As-built" controls submittal

b. Pre-functional Checklists

c. Start-Up Binder with completed testing and start-up reports

d. Completed Functional Performance Test records

e. Trend data

f. A list of deficiencies referenced to a specific FPT section

g. Final TAB Report

3.11 TRAINING OF OWNER PERSONNEL

A. Sub-contractors will provide complete training in startup, operation and maintenance of all equipment under contract.

B. CA will be responsible for overseeing and approving content and adequacy of Facility Staff training.

C. Sub-contractor responsible for training will submit a written training plan to CA for review and approval prior to training. Plan will cover the following elements:

1. Equipment (included in training)

2. Intended audience

3. Location of training

4. Objectives

5. Subjects covered

6. Duration of training on each subject

7. Instructor for each subject

8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

9. Instructors and qualifications

D. CA coordinates and schedules training with CM, DFM and Sub-contractors. CA develops criteria to determine training satisfactorily completed. CA schedules training sessions with appropriate personnel.

E. CA will provide videotaping of training sessions as required.

3.12 DEFERRED TESTING

A. Deferred Seasonal Testing: During warranty period, seasonal testing (tests delayed until weather conditions are closer to system's design) will be completed as part of this contract. CA will coordinate this activity. Tests will be executed, documented and deficiencies corrected by appropriate contractor(s), with DFM, OR and CA witnessing. CA will incorporate final updates to Commissioning Turnover Package as necessary.

B. Unforeseen Deferred Tests: Any check or test not completed due to building structure, required occupancy condition, or other deficiency, may be delayed upon approval of OR. These tests will be rescheduled as soon as possible.

3.13 FUNCTIONAL PERFORMANCE TESTS AND TEST PROCEDURES

A. FCU Functional Performance Test

1. The FCU FPT is to be conducted after the hydronic water balance and air side T&B for the spaces served by the FCU are complete. Portions of this FPT also require that the chilled water and heating water systems operate to produce chilled water and heating water at design temperatures. The FCU FPT requires a 24-hour trend at 3 minute intervals of FCU and chilled water system parameters listed in the FPT procedure. The trending should be scheduled to ensure that fire alarm tests or other activities do not shut down the AHU or hydronic systems during the 24-hour period.

2. In the Functional Performance Tests Section (Tab 3) there is an example of FCU FPT (including templates for calculating and displaying the trend data) for the FCU sequence of operation contained in this document.

B. BAS/ESC connectivity Functional Performance Test – Coordinate with HCA corporate FacilitiGroup Energy Service center to verify full BAS communication between the facility and ESC.

3.14 PRE-FUNCTIONAL CHECKLISTS

A. 220500 – Common Work Results for Plumbing. This is for general pipe inspection and spans several different specification sections.

| | | |
|---|---|---|
| | Sleeves are installed on piping passing through masonry walls and floors | |
| | Air separator and expansion tank are installed and piped | |
| | Expansion tank has been properly charged | |
| | Air vents are provided at high points throughout the system | |
| | Drain valves are provided at low points throughout the system | |
| | Shutoff valves are installed at main branches on each floor or major wings or sections | |
| | CHW piping is insulated with closed-cell type and undamaged | |
| | System has been cleaned and flushed | |

| **Domestic Hot Water Piping** | | **Y/N/NA; Initials; Date** |
|---|---|---|
| | Piping in mechanical rooms are painted and labeled identifying contents and flow direction | |
| | Piping is labeled in 20 foot intervals and at least once in each separate space | |
| | Pipe is supported properly per the contract documents | |
| | Sleeves are installed on piping passing through masonry walls and floors | |
| | Air separator and expansion tank are installed and piped | |
| | Expansion tank has been properly charged | |
| | Air vents are provided at high points throughout the system | |
| | Drain valves are provided at low points throughout the system | |
| | Shutoff valves are installed at main branches on each floor or major wings or sections | |
| | HW piping is insulated with molded fiberglass and undamaged | |
| | Piping 2" and larger are supported with high density insulation inserts and not wood blocks | |
| | System has been cleaned and flushed | |

| **Condensate Piping** | | **Y/N/NA; Initials; Date** |
|---|---|---|
| | Piping in mechanical rooms are painted and labeled identifying contents and flow direction | |
| | Piping is labeled in 20 foot intervals and at least once in each separate space | |
| | Pipe is supported properly per the contract documents | |
| | Sleeves are installed on piping passing through masonry walls and floors | |
| | Condensate piping is insulated with molded fiberglass and undamaged | |
| | Piping 2" and larger are supported with high density insulation inserts and not wood blocks | |

| **Ductwork** | | **Y/N/NA; Initials; Date** |
|---|---|---|
| | Duct is properly supported per the contract documents | |
| | Mechanical room duct floor penetrations and plenum floor penetrations are installed with 2" curb | |
| | Duct insulation is complete and undamaged | |

| **Notes** | | **Date** |
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| Condensate Piping | | Y/N/NA; Initials; Date |
|---|---|---|
| | Piping in mechanical rooms are painted and labeled identifying contents and flow direction | |
| | Piping is labeled in 20 foot intervals and at least once in each separate space | |
| | Pipe is supported properly per the contract documents | |
| | Sleeves are installed on piping passing through masonry walls and floors | |
| | Condensate piping is insulated with molded fiberglass and undamaged | |
| | Piping 2" and larger are supported with high density insulation inserts and not wood blocks | |

| Ductwork | | Y/N/NA; Initials; Date |
|---|---|---|
| | Duct is properly supported per the contract documents | |
| | Mechanical room duct floor penetrations and plenum floor penetrations are installed with 2" curb | |
| | Duct insulation is complete and undamaged | |

| Notes | | Date |
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**Approvals**

| | | |
|---|---|---|
| **Mechanical Contractor / Signature** | | **Company:** |
| **General Contractor / Signature** | | **Company:** |

B. 232123 – Hydronic Pumps

[Insert Your Logo Here] [Vendor Logo Here]

# Hydronic Pump Pre-Functional Checklist

| | | | | |
|---|---|---|---|---|
| | **Facility Name:** | | **Date:** | |
| | **Project Name:** | | | |
| | **Pump Tag:** | | | |
| 1 | **Manufacturer:** | | | |
| 2 | **Model #:** | | | |

| | **General** | **Y/N/NA; Initials; Date** |
|---|---|---|
| 3 | Pump is installed and bolted to housekeeping pad | |
| 4 | Inertia base is installed correctly per contract documents | |
| 5 | Vibration springs are properly adjusted and free floating | |
| 6 | Coupling guard is installed | |
| 7 | Unit is clean | |
| | **Piping** | **Y/N/NA; Initials; Date** |
| 8 | Isolation valves are installed on supply and return piping for service | |
| 9 | Piping is connected to pump with flanges to allow service | |
| 10 | Piping is properly supported and not supported by the pump | |
| 11 | First three pipe hangers on suction and discharge piping at pump are installed with vibration spring isolators | |
| 12 | Flex connections are installed on supply and return piping | |
| 13 | Suction diffuser is installed with access to pull strainer | |
| 14 | Adjustable foot support is installed on suction diffuser | |
| 15 | Blowdown valve is installed at suction diffuser and piped to floor drain | |
| 16 | Check valve is installed on discharge of pump | |
| 17 | Balancing valve is installed on discharge piping | |
| 18 | Glycerin filled pressure gauge is installed at flange of suction diffuser, pump inlet, and pump outlet with each line and pressure gauge having a shutoff valve | |
| 19 | Control wells are installed | |
| 20 | Clearances have been maintained and piping is installed for service | |
| 21 | One shot chemical feeder is installed across suction and discharge of pump with isolation valves | |
| 22 | One shot feeder is installed with drain valve | |
| | **Electrical/Controls** | **Y/N/NA; Initials; Date** |
| 23 | Power is connected to pump | |
| 24 | Starter/VFD is installed and clean | |
| 25 | Control wiring is complete and terminated | |
| | **Insulation & Labeling** | **Y/N/NA; Initials; Date** |
| 26 | Piping insulation is complete and undamaged | |
| 27 | Chilled water pumps are installed with insulated box around pipe connections | |
| 28 | Valves are tagged with permanent engraved labels | |
| 29 | Pump is clearly labeled | |
| 30 | Piping is painted and labeled with contents and flow direction | |
| | **Start-Up** | **Y/N/NA; Initials; Date** |
| 31 | Factory representative start-up completed and documents provided | |
| | **Notes** | **Date** |
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**Approvals**

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|---|---|---|
| **Mechanical Contractor / Signature** | | **Company:** |
| **General Contractor / Signature** | | **Company:** |

C. 236500 – Cooling Towers

[Insert Your Logo Here] [Vendor Logo Here]

# Cooling Tower Pre-Functional Checklist

| | | | |
|---|---|---|---|
| | **Facility Name:** | **Date:** | |
| | **Project Name:** | | |
| | **Cooling Tower #:** | | |
| 1 | **Manufacturer:** | | |
| 2 | **Model #:** | | |

| | **General** | **Y/N/NA; Initials; Date** |
|---|---|---|
| 3 | Cooling tower is installed and bolted on support frame | |
| 4 | Hot and cold water basins are stainless steel with the remainder of the tower being galvanized | |
| 5 | Entire cooling tower is stainless steel if located within 60 miles of coast | |
| 6 | Cooling tower cold water basin is installed at a higher elevation than the condenser water pump (Minimum of 3 feet) | |
| 7 | Platform is provided with ladder for access to service tower and motor | |
| 8 | Adequate clearance is provided for airflow at intake | |
| 9 | Belts properly installed and protected | |
| 10 | Factory installed sweeper eductor system is provided | |
| 11 | Skid mounted separator package is provided and piped to condenser water system | |
| 12 | Unit is clean | |
| 13 | VFD is provided and installed | |
| | **Piping** | **Y/N/NA; Initials; Date** |
| 14 | Isolation valves are installed on supply and return piping for service | |
| 15 | Automatic control isolation valve installed at cooling tower | |
| 16 | Piping is properly supported and not supported by the cooling tower | |
| 17 | Equalizer line is installed with isolation valve for cleaning of each basin | |
| 18 | Drain valves are installed at low point | |
| 19 | Clearances have been maintained and piping is installed for service | |
| 20 | Water meter is installed on makeup water piping | |
| | **Electrical/Controls** | **Y/N/NA; Initials; Date** |
| 21 | Power is connected to cooling tower | |
| 22 | Electronic basin level control is provided | |
| 23 | Vibration safety switch is installed and wired on tower | |
| 24 | Basin heater installation is complete | |
| 25 | Controls wiring and sensors are installed and complete | |
| | **Insulation & Labeling** | **Y/N/NA; Initials; Date** |
| 26 | Piping insulation is complete and undamaged | |
| 27 | Conductivity probe chamber is insulated and heat-traced to prevent freezing | |
| 28 | Outdoor piping is insulated and heat traced | |
| 29 | Cooling Tower is clearly labeled | |
| 30 | Piping is labeled with contents and flow direction | |
| | **Start-Up** | **Y/N/NA; Initials; Date** |
| 31 | Flushing of piping is complete and flushing connection lines are removed, capped, and valve handles removed prior to start-up | |
| 32 | Bearings lubricated on fans and shaft. Grease Zerks are readily accessible | |
| 33 | Gearbox is lubricated | |
| 34 | Factory representative start-up completed and documents provided | |

| | **Notes** | **Date** |
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**Approvals**

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| **Mechanical Contractor / Signature** | | **Company:** |
| **General Contractor / Signature** | | **Company:** |

D. 238219 – Fan Coil Units

[Insert Your Logo Here] [Vendor Logo Here]

## Fan Coil Unit Pre-Functional Checklist

| | | | |
|---|---|---|---|
| | **Facility Name:** | **Date:** | |
| | **Project Name:** | | |
| | **FCU #:** | | |
| 1 | **Manufacturer:** | | |
| 2 | **Model #:** | | |

| | **General** | **Y/N/NA; Initials; Date** |
|---|---|---|
| 3 | Unit is properly mounted with spring isolators | |
| 4 | Unit is installed with access for service of fan and electrical panel | |
| 5 | Filter access is provided for maintenance | |
| 13 | Unit is clean | |
| | **Chilled Water Coil** | **Y/N/NA; Initials; Date** |
| 14 | Isolation valves are installed on supply and return piping for service | |
| 15 | Piping is properly supported and not supported by the coil | |
| 16 | Unions are provided at coil connections for access | |
| 18 | Clearances have been maintained and piping is installed for service | |
| 19 | Coil drain with valve is installed at low point of coil | |
| 20 | Manual air vent is installed at high point in coil | |
| 22 | PT Ports are installed on supply and return piping directly at coil connection and at all temperature sensors | |
| 23 | Balancing valve is installed in return piping with recommended straight length upstream and downstream of valve | |
| 24 | Control valve is installed in the return piping | |
| 27 | Temperature sensor is installed in return piping | |
| 29 | Temporary flushing connection is installed with valves to bypass coil during flushing | |
| 30 | Coil is piped counterflow (coldest water to coldest air) | |
| 31 | Control wells are installed | |
| | **Condensate Piping** | **Y/N/NA; Initials; Date** |
| 33 | Condensate drain is full line size with union | |
| 34 | Condensate drain is installed with clean out plug at tee | |
| 35 | Open vent is installed after trap | |
| | **Heating Hot Water Coil** | **Y/N/NA; Initials; Date** |
| 57 | Isolation valves are installed on supply and return piping for service | |
| 58 | Unions are provided at coil connections for access | |
| 60 | Piping is properly supported and not supported by the coil | |
| 61 | Coil drain with valve is installed at low point of coil | |
| 62 | Manual air vent is installed at high point in coil | |
| 64 | PT Ports are installed on supply and return piping directly at coil connection and at all temperature sensors | |
| 66 | Balancing valve is installed in return piping with recommended straight length upstream and downstream of valve | |
| 67 | Control valve is installed in the return piping | |
| | **Electrical/Controls** | **Y/N/NA; Initials; Date** |
| 114 | Power is connected to unit | |
| 127 | Controls wiring and sensors are installed and complete | |
| | **Insulation & Labeling** | **Y/N/NA; Initials; Date** |
| 128 | Piping insulation is complete and undamaged | |
| 129 | Duct insulation is complete and undamaged | |
| 130 | Condensate drain line insulation is complete and undamaged | |
| 131 | Engraved label for unit is installed and clearly visible | |
| 132 | Piping is painted and labeled with contents and flow direction | |
| 133 | Valves are tagged with permanent engraved labels | |
| | **Start-Up** | **Y/N/NA; Initials; Date** |
| 134 | Flushing of piping is complete and flushing connection lines are removed, capped, and valve handles removed prior to start-up | |
| 135 | Unit and all ductwork are protected prior to being used for temporary conditioning of space | |
| 136 | Start-up is complete and documents provided | |

| | **Notes** | **Date** |
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**Approvals**

| | | |
|---|---|---|
| **Mechanical Contractor / Signature** | | **Company:** |
| **General Contractor / Signature** | | **Company:** |

# SECTION 22 05 00

# COMMON WORK RESULTS FOR PLUMBING

## PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. In addition to Division 01 Specification Sections, related sections include the following:

1. Division 01 Section "Cutting and Patching"

2. Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

3. Division 03 Sections "Cast-in-Place Concrete" and "Miscellaneous Cast-in-Place Concrete".

4. Division 05 Section "Metal Fabrications" for structural steel.

5. Division 09 Sections "Interior Painting" and "Exterior Painting".

6. Division 08 Section "Access Doors and Frames" for access panels and doors.

1.2 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items to the Contractor, but in no way relieve him of the responsibility of reading and complying with all relevant parts of the entire Specification.

B. The Contractor shall examine and coordinate with all Contract Drawings and Specifications, and all Addenda issued. Failure to comply shall not relieve them of responsibility. The omission of details of other portions of the Work from this Division shall not be used as a basis for a request for additional compensation.

C. The specific features and details for other portions of the Work related to the construction in progress or to the existing building(s) shall be determined by examination at the site.

1.3 INNOVATION MEMORANDUMS

A. The Owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.

1. Innovation Memorandum No. 6: All plumbing fixtures and drains to be purchased from Ferguson Enterprises. Contact Alton Lassiter, office (615)

316-1848, cell (615) 812-6500, or email HCA@ferguson.com. Refer to Division 22 Sections Domestic Water piping Specialties.

2. Innovation Memorandum No. 7: All piping, valves, pipe fittings, and related products to be purchased from Ferguson Enterprises. Contact Alton Lassiter, office (615) 316-1848, cell (615) 812-6500, or email HCA@ferguson.com. Refer to Division 22 Sections General Duty Valves for Plumbing Piping, Domestic Water Piping.

3. Innovation Memorandum No. 7a: Press piping must be approved in advance by HCA Healthcare Capital Deployment construction management. The only manufacturer allowed is Viega. Press fittings are allowed only on domestic water. Subcontractors will qualify to install Viega fittings by having a minimum of three years of experience, receive Viega-led training on all HCA projects resulting in becoming a certified installer and carry proof of current certification at all times on the job. Viega to provide formal training for all projects and provide record to HCA of the companies/employees trained, focusing heavily on installation and testing procedures outlined in the General Applications document. Ferguson Enterprises, Viega, HCA and the subcontractor will certify the project, keep records of file and align project with HCA project numbers. All pipe fittings and related products to be purchased from Ferguson Enterprises. Contact Alton Lassiter, office (615) 316-1848, cell (615) 812-6500, or email HCA@ferguson.com. HCA Construction Manager to be notified of intent to use ProPress. Refer to Division 23 Section "Domestic Water Piping".

4. Innovation Memorandum No. 25: Project shall comply with 2020 MEP Guidelines.

1.4 SUMMARY

A. This Section includes the following:

1. Scope of work.

2. Piping materials and installation instructions common to most piping systems.

3. Transition fittings.

4. Dielectric fittings.

5. Mechanical sleeve seals.

6. Sleeves.

7. Escutcheons.

8. Grout.

9. Plumbing demolition.

10. Equipment installation requirements common to equipment sections.

11. Painting and finishing.

12. Concrete bases.

13. Supports and anchorages.

1.5 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. Products and Materials: Components and assemblies for the construction of the systems as indicated in the Documents including, but not limited to pipes, tubes, valves, and equipment.

G. Products or Materials: See "Products and Materials".

H. Provide: The materials and equipment described shall be furnished, installed and connected under this Division, complete for operation, unless specifically noted to the contrary. Identical to the phrase "furnish and install".

I. Furnish: The material, equipment, etc. to be supplied, but not installed by the supplier.

J. The following are industry abbreviations for materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.

2. PE: Polyethylene plastic.

3. PVC: Polyvinyl chloride plastic.

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

5. NBR: Acrylonitrile-butadiene rubber.

K. VFD: Variable frequency drive. This may be used interchangeably with VSD (variable speed drive), VSC (variable speed controller), and VFMC (variable frequency motor controller). This technology varies the frequency of the incoming electrical signal to change the speed of driven equipment.

1.6 SCOPE OF WORK

A. Inspection Of Site

1. The accompanying drawings do not indicate existing plumbing installations other than to identify modifications of and extensions thereof. The Contractor shall visit the site, inspect the installations and ascertain the conditions to be met and the work.

2. Failure to comply with an inspection of the site shall not constitute ground for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work under this Division.

3. Review construction details of the existing portion of the building during the site inspection and include all work required to modify the existing plumbing installations and install new materials, comprising a part of the plumbing installation, within the present structure.

B. Products and Materials Description

1. Where two or more units of the same kind or class of a specific item are required, these shall be the products of a single manufacturer; however, the component parts of the item need not be the products of one manufacturer.

2. In describing the various products and materials, in general each item will be described singularly, even though there may be a multiplicity of identical items. Also, where the description is only general in nature, exact sizes, duties, space arrangements, horsepower requirements and other data shall be determined by reference to the Documents.

C. The Work shall include modifications and extensions to existing systems, and the modification of the existing structure as required accommodating the installation of the Work.

D. Refer to other Divisions of the Specifications for related Work.

E. Contractor shall install, hang, support, etc. all MEP systems and equipment to satisfy all requirements of the applicable seismic zone using performance requirements and design criteria for project site as indicated by architect.

F. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases "install", "furnish", "furnish and install", or "provide" as described above has been actually included.

G. The Contractor shall be responsible for all Work of every description in connection with this Division of the Specifications.

H. The Contractor shall specifically and distinctly assume, and does so assume, all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.

I. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

J. The Contractor shall provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

K. Electric wiring

1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:

   a. Temperature Control Wiring and Power Wiring provided by controls contractor.

2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.

3. All domestic cold and hot water piping shall be heat traced when routed external to the building or in areas susceptible to freezing conditions.

1.7 ORDINANCES, PERMITS AND CODES

A. It shall be the Contractor's duty to perform the work and provide the materials covered by these specifications in conformance with all ordinances and regulations of all authorities having jurisdiction.

B. All work herein shall conform to all applicable laws, ordinances, and regulations of the local utility companies.

C. The work shall be in accordance with, but not limited to, the requirements of:

1. National Fire Protection Association

2. National Safety Code

3. Lee's Summit Building Codes

4. Missouri Safety Code

5. Missouri Boiler Code

6. Missouri Department Of State Health Services

D. Codes and standards referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes and regulations, the drawings, and specifications govern.

E. The Contractor shall obtain permits, plan checks, connection and specification fees, inspections, and approvals applicable to the Work as required by the regulatory authorities.

F. Fees and costs of any nature whatsoever incidental to permits, inspections, and approvals shall be assumed and paid by the Contractor.

G. The pro-rata costs, if any, for utilities serving this property will be paid for by the Owner and shall not be included as part of this Contract.

1.8 REFERENCE STANDARDS

A. Where differences between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents occur, the most stringent shall govern. The Contractor shall promptly notify the Owner's Representative in writing of any such difference.

B. Should the Contractor perform any Work that does not comply with local codes, laws and ordinances, industry standards or other governing regulations, the Work shall be corrected on noncompliance deficiencies with the Contractor bearing all costs.

C. In addition to the aforementioned ordinances, industry standards published by the following organizations shall apply:

1. AIA AMERICAN INSTITUTE OF ARCHITECTS

2. AASHO AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS

3. ACI AMERICAN CONCRETE INSTITUTE

4. AGA AMERICAN GAS ASSOCIATION

5. AISC AMERICAN INSTITUTE OF STEEL CONSTRUCTION

6. ANSI AMERICAN NATIONAL STANDARDS INSTITUTE

7. API AMERICAN PETROLEUM INSTITUTE

8. ARI AIR CONDITIONING & REFRIGERATION INSTITUTE

9. ASHRAE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONS ENGINEERS, INC.

10. ASME AMERICAN SOCIETY OF MECHANICAL ENGINEERS

11. ASTM AMERICAN SOCIETY FOR TESTING AND MATERIALS

12. AWSC AMERICAN WELDING SOCIETY CODE

13. AWWA AMERICAN WATER WORKS ASSOCIATION

14. CISPI CAST IRON SOIL PIPE INSTITUTE

15. ASPE AMERICAN SOCIETY OF PLUMBING ENGINEERS

16. FM FACTORY MUTUAL

17. IRI INDUSTRIAL RISK INSURERS

18. NBS NATIONAL BUREAU OF STANDARDS

19. NFPA NATIONAL FIRE PROTECTION ASSOCIATION

20. PDI PLUMBING AND DRAINAGE INSTITUTE

21. UL UNDERWRITER'S LABORATORIES

D. Where the Contract Documents exceed the above requirements, the Contract Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.

1.9 DRAWINGS AND SPECIFICATIONS

A. The inter-relation of the specifications, the drawings, and the schedules are as follows:

1. The specifications provide the written requirements for the quality, standard, nature of the materials, equipment and construction systems.

2. The drawings establish the quantities, approximate dimensions, details and location of equipment.

3. The schedules give the capacities, characteristics and components.

B. For any individual project, if there is conflict between the drawings and or specifications, they are equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements the resolution shall be determined by the Architect.

C. Contractor is responsible to bring any conflicts in drawings and/or specifications to the attention of the Architect, immediately, prior to any work being done.

D. Where the specifications do not fully agree with the schedules, the schedules shall govern. Figures given on drawings govern scale measurements and large scale details govern small scale drawings.

E. Review all construction details illustrated on the architectural and structural drawings and be guided thereby.

1.10 SUBMITTAL PROCEDURES

A. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Submit Product Data in electronic format. Files shall be provided in Portable Document Format (.pdf).

a. Submit digital copies of Product Data as required under Division 01.

b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique section identification heading for ease of navigation.

2. In addition to digital copies, hardcopies of Product Data may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

3. Product Data shall not consist of manufacturer's catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.

B. Common Requirements for Shop Drawings and Coordination Drawings: Where this Section and other Sections of this Division require Shop Drawings or Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section "Project Management and Coordination". In addition to the requirements of Division 01 comply with the following:

1. Prepare Shop Drawings and Coordination Drawings in accordance with project's approved BIM Management Plan.

2. Prepare Shop Drawings and Coordination Drawings using computerized modeling software compatible with AutoDesk's Revit®, AutoCAD®, or Navisworks®. Drawings files must be composite with multiple distinctive layers for each of the various trades.

3. Shop Drawings and Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale as follows:

a. Piping Systems, Sheet Metal and Duct System, including all underfloor work: Minimum 1/8-inch equals one foot.

b. Mechanical rooms: Minimum 1/4-inch equals one foot.

c. Piping and equipment systems for storm, domestic water, waste and vent and other plumbing piping systems: Preferably at 1/4-inch equals one foot and not less than 1/8-inch equals one foot.

d. Plumbing Equipment room: Minimum 1/4-inch equals one foot. Show clearances, access spaces, relative heights of piping.

4. Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.

5. Submit Shop Drawings and Coordination Drawings in electronic format. Files shall include both AutoDesk® compatible source files and files printed to Portable Document Format (.pdf).

a. Submit digital copies of Shop Drawings and Coordination Drawings as required under Division 01.

b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique sheet identification number for ease of navigation.

6. In addition to digital copies, hardcopies of Shop Drawings or Coordination Drawings may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

C. Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for "Other Informational Submittals". In addition to the requirements of Division 01 comply with the following:

1. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with "Compliance". Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.

b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.

c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.

d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.

D. Common Requirements for Qualification Data:

1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of registration in the Project location.

2. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; Submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

1.11 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.

2. Mechanical sleeve seals.

3. Escutcheons.

1.12 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:

1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.

2. Plumbing Equipment Room Layouts: Floor plans, elevations, and other necessary details showing dimensioned layouts for spaces containing plumbing equipment. Base plumbing equipment dimensions on exact dimensioned data obtained from product submittals for products to be

included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

a. Equipment layout and relationships between components and adjacent structural and mechanical elements, including piping and ductwork.

b. Equipment room layouts with actual dimensions, working clearances, required area above and around equipment, and offsets for all systems.

c. Location of luminaires, sprinkler piping and heads, ducts, and diffusers.

d. Equipment support locations, type of support, and weight on each support.

e. Location of structural supports for structure-supported piping.

f. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

g. Trench locations and sizes.

h. Dimensioned floor drain locations and the equipment each serves.

3. Roof layouts.

B. Welding certificates.

1.13 SUBSTITUTIONS

A. Where the product of a single manufacturer is mentioned by trade name or manufacturer's name in this Division, it is the only acceptable manufacturer.

B. Where two or more manufacturers are named, only those manufacturers will be considered or approved.

C. Manufacturers not listed will be considered for substitution prior to bid only. The substitute manufacturer shall submit a complete copy of the appropriate technical specification section minimum ten (10) business days prior to bid with each sub-paragraph noted with the comment, "compliance", "deviation", "alternate" or "not applicable". In the case of non-primary, vendor-supplied items, the name of the sub-vendor supplying said item, including model number, shall be indicated.

1. By noting the term "compliance" or "C", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.

2. By noting the term "deviation" or "D", it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified. Manufacturer shall indicate all deviations.

3. By noting the term "alternate" or "A", it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner. An alternate shall be fully described as to what the manufacturer proposes to provide.

4. By noting the term "not applicable" or "N/A", it shall be understood that the specified item is not applicable to the project.

D. It shall be understood that space allocations have been made on the basis of present and known future requirements and the dimensions of items of equipment or devices of a particular manufacturer whether indicated or not.

E. Any product or material offered in substitution which differs in dimension or configuration from the Documents, the Contractor shall provide as part of the submittal a drawing, minimum 1/4" = 1'-0" scale, showing that the substitution can be installed in the space available without interfering with other portions of the work or with access for operations and maintenance in the completed project.

F. Where substitute products or materials requiring different arrangement or connections from that indicated is accepted by the Owner's Representative, install the equipment or devices to operate properly and in harmony with the intent of the Documents, making all incidental changes in piping or wiring resulting from the substitution without any additional cost to the Owner.

G. The Contractor shall pay all additional costs incurred by other portions of the work in connection with all substitutions.

H. The Owner's Representative reserves the right to call for samples of any item of product or material offered in substitution, together with a sample of the specific item when, in their opinion, the quality of the item and/or the appearance is involved, and it is deemed that an evaluation of the item may be better made by visual inspection.

I. When any request for a substitution of a product or material is submitted and rejected, the item named in the Documents shall be furnished. Repetitive submittal of substitutions for the same item will not be considered.

1.14 QUALITY ASSURANCE

A. All Work shall be performed by properly licensed technicians skilled in their respective trades. All materials, equipment and devices shall be installed in accordance with the recommendations of the manufacturer and in the best standard practice to bring about results of a first class condition.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. Electrical Characteristics for Plumbing Equipment:

1. Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

2. Where variable frequency drives are provided for equipment, whether installed separately or integral to the equipment, the VFDs shall conform to Division 26 section, "Variable Frequency Motor Controllers".

E. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided on this project shall meet the requirements of the UL standard in every way, and shall be UL listed and labeled.

F. Products and materials shall be of the best quality customarily applied in quality commercial practice, and shall be by reputable manufacturers.

G. Each major component shall bear a nameplate giving the name and address of the manufacturer, and the catalog number or designation of the component.

H. Products and materials provided under this Division of the Specifications shall be essentially the standard item, unless otherwise noted, of the specified manufacturer, or where allowed, an alternate manufacturer.

1.15 DELIVERY, STORAGE, AND HANDLING

A. Deliver products and materials with factory-applied end caps or "heat shrink" wrappings to protect openings. Maintain opening protection through shipping, storage, and handling to prevent damage and the entrance of dirt, debris, and moisture.

B. Store light sensitive products and materials away from and protected against direct sunlight.

C. Support products and materials at all times to prevent sagging and bending.

D. The area provided for product and material storage at the jobsite shall be clean, dry and exposure to dust minimized.

E. Responsibility for the protection of products and materials shall extend to existing equipment, systems, and products and materials. Erect temporary sheltering structures, provide temporary bracing and supports, or cover existing equipment, systems, and products and materials to prevent damage and the entrance of dirt, debris, and moisture.

F. Failure on the part of the Contractor to comply with the above to the satisfaction of the Architect, Engineer, or either's authorized representative shall be sufficient cause for the rejection of products and materials in question.

1.16 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces.

D. Installation Drawings

1. Prepare special drawings as called for elsewhere herein or directed by the Architect to coordinate this work with the work of other Divisions, to illustrate changes in this work to facilitate its concealment in finished spaces, to avoid obstructions, or to illustrate the installation of a substitute equipment item.

2. Use these drawings in the field for the installation of the work. Unless otherwise directed, do not submit these drawings for review, but provide 3 copies to the Architect for information.

E. Schedule And Sequence Of Work

1. The Contractor shall meet and cooperate with the Owner and Owner's Representative to schedule and sequence Work so as to ensure meeting scheduled completion dates and avoid delaying other portions of the Work. Work requiring special sequencing shall be at no additional cost to the Owner and shall have no impact on the schedule.

2. Work schedules and completion dates as established shall be rigidly adhered to. Cooperate in establishing these schedules and perform the work under this Division at such times as directed so as to ensure meeting scheduled dates and avoid delaying any other Contractor.

3. The facility will continue to be in use throughout the construction period, and the schedule contemplates working in designated areas in the present facility while other adjacent areas are occupied. Execute work in this Division to minimize disturbance to occupants in adjacent areas.

4. When any work affects any services to any occupied area new permanent or temporary services, or a combination of both, shall be installed to enable occupied areas to function properly. Additional valves required shall be installed without added cost to the Owner.

5. Perform no work in the present facility that interferes with normal hours of occupancy, unless special permission is granted by the Owner. Included are

operations which would cause objectionable noise or service interruptions. Each discipline shall coordinate their work with the established phases of construction.

6. Any work involving a service suspension shall be scheduled in advance with the Owner.

7. Should it be necessary to perform certain operations on an "overtime" basis in order not to interrupt the normal usage of the facility, include the costs of such overtime without change in the Contract amount.

8. The Contractor shall be responsible for coordinating the demolition and tie-in of the central plant system with the Owner and construction manager.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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 manufacturers specified.

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

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

C. All piping and tubing shall be American manufactured, unless otherwise indicated.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

D. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

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

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

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

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

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Innerlinx by Mason Dallas.

b. Metraflex Co.

c. Linkseal by Thunderline.

2. Sealing Elements: EPDM for high temperature applications and NBR for all others unless otherwise indicated, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, galvanized, plain ends.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.

C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.

D. One-Piece, Floor-Plate Type: Cast-iron floor plate.

E. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

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

3. Packaging: Premixed and factory packaged.

## PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.

3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 SALVAGED MATERIALS

A. Reuse no salvaged material except as noted on the Drawings, specified herein, or directed by the Architect. Remove from the premises all present materials falling under this Division, which are removed from the existing building. Upon completion, leave no "dead" line or equipment installed in any portion of the area being remodeled.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons, after Architect's final approval of finish, for penetrations of walls, ceilings, and floors according to the following:

1. New piping penetrations shall be one-piece escutcheons.

2. Existing piping penetrations shall be two-piece escutcheons.

3. All sleeved penetrations shall be deep-drawn to allow flush installation between escutcheon and finished surface.

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

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

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level to prevent water entrance to the sleeved hole. Vertical pipe supports must be extended to and supported by the floor and not the sleeve.

b. Strike above subparagraph and retain subparagraph below when a pipe curb is required at all floor penetrations in lieu of extended sleeves.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.

b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

N. Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter for above ground locations.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter for above ground and all underground locations.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.

4. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

K. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.5 PIPING CONNECTIONS

A. 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Equipment called for on the plans and not listed herein shall be provided as though it were fully described herein.

B. Equipment called for herein shall be completely provided, whether fully detailed or not on the plans, and/or scheduled.

C. All equipment as indicated on the plans and as described herein shall be installed per manufacturer's recommendations to allow for proper operation and maintenance of the equipment.

D. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

E. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

F. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

G. Where any piece of equipment is too large for ingress through normal building openings, it shall be placed in its containing space before the enclosing structure is completed.

H. Install equipment to allow right of way for piping installed at required slope.

3.7 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases not less than 4 inches larger in both directions than supported unit.

2. Concrete bases for all equipment shall be 6 inches tall above finished floor.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.11 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.12 INSTALLATION, INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.

B. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Architect for transmission to the Owner.

3.13 OPERATION PRIOR TO COMPLETION

A. When any piece of mechanical or electrical equipment is operable and it is to the advantage of the contractor to operate the equipment, he may do so with permission of Owner, providing that he properly supervises the operation, retains full responsibility for the equipment operated, and protects against dirt accumulations during operation. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner or until final acceptance by the Owner.

B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, and properly adjust the operation of the equipment before final acceptance by the Owner.

3.14 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of competent engineers and/or technicians acceptable to the Owner's Representative to instruct other representatives of the Owner in the complete and detailed operation of each item of equipment or device of all the various electrical systems. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results.

B. Upon completion of these instructions, the Contractor shall obtain a letter of release, acknowledged by the Owner or his authorized representative, stating the dates on which the various kinds of instruction were given, and the personnel to whom the instructions were given.

C. The Contractor shall be fully responsible for proper maintenance of equipment and systems until the instructions have been given the Owner's personnel and the letter of release acknowledged.

D. In providing the instructions to the Owner's personnel, the written operating and maintenance manuals shall be followed in all instances, and the Owner's personnel shall be familiarized with such manuals.

E. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturer's operating and maintenance instructions, parts lists (with sources identified), and other data as appropriate for each system.

**END OF SECTION**

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# SECTION 22 05 19

# METERS AND GAGES FOR PLUMBING PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermometers.

2. Gages.

3. Test plugs.

B. Related Sections:

1. Division 22 Section "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.

2. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

3. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

4. Division 23 Section "Instrumentation and Control for HVAC"

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

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

1.3 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

C. Shop Drawings: Schedule for thermometers, gauges, and flowmeters indicating manufacturer's number, scale range, and location for each.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

## PART 2 - PRODUCTS

2.1 THERMOMETERS

A. Digital Vari-angle Thermometer, self-powered and within 1% accuracy, Weiss Model DVU35, indoor use only.

1. Case: Hi-impact ABS
2. Range: -50/300 °F (-45/150 °C)
3. Display: 1/2" LCD digits, wide ambient formula
4. Accuracy: 1% of reading or 1° whichever is greater
5. Resolution: 1/10° between -19.9/199.9 °F (-28/93 °C)
6. Recalibration: Internal potentiometer
7. Lux Rating: 10 Lux (one foot-candle)
8. Update Rate: 10 seconds
9. Ambient Operating Range: -30/140 °F (-35/60 °C)
10. Ambient Temp. Error: Zero
11. Humidity: 100%
12. Sensor: Glass passivated thermistor
13. Connector: Adjustable Angle

B. Digital Vari-angle Thermometer, self-powered and within 1% accuracy, Weiss Model 5DVBM, exterior use.

1. Case: 5" Hermetically Sealed St. St.
2. Range: -50/300 °F (-45/150 °C)
3. Display: 1/2" LCD digits, wide ambient formula
4. Accuracy: 1% of reading or 1° whichever is greater
5. Resolution: 1/10° between -19.9/199.9 °F (-28/93 °C)

6. Recalibration: Internal potentiometer

7. Lux Rating: 10 Lux (one foot-candle)

8. Update Rate: 10 seconds

9. Ambient Operating Range: -30/140 °F (-35/60 °C)

10. Ambient Temp. Error: Zero

11. Sensor: Glass passivated thermistor

12. Connector: Adjustable Angle

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type 304 stainless steel fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAGES

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

1. Ernst Gage Co.

2. Miljoco Corp.

3. Trerice, H. O. Co.

4. Weiss Instruments, Inc.

5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

6. Dwyer Instruments, Inc.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Liquid-filled type, cast aluminum, 4 1/2-inch (114-mm) diameter.

2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.

3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.

4. Movement: Mechanical, with link to pressure element and connection to pointer.

5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

6. Pointer: Red or Black metal.

7. Window: Glass.

8. Ring: Stainless steel.

9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.

10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 50 psig of pressure.

11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel ball type.

2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

3. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.

2.4 TEST PLUGS

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

1. Flow Design, Inc.

2. MG Piping Products Co.

3. National Meter, Inc.

4. Peterson Equipment Co., Inc.

5. Sisco Manufacturing Co.

6. Trerice, H. O. Co.

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

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

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20 to 200 deg F shall be CR.

2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

## PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install digital thermometers in the following locations:

1. Inlet and outlet of each domestic water heater.

2. Inlet and outlet of each thermostatic mixing valve.

B. Install Indoor and Outdoor type thermometers according to Part 2 Products above.

C. Install thermometers in separable sockets at each additional location indicated on the Drawings or specified elsewhere herein.

D. Provide the following temperature ranges for thermometers:

1. Domestic Hot Water: 30 to 200 deg F, with 2-degree scale divisions.

2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE COCK APPLICATIONS

A. Install test plugs adjacent to all control sensors (except Insertion Type Flow Meters) installed in piping systems.

B. Valved pressure gage connections shall be installed in each location indicated on the Drawings and/or specified elsewhere herein.

C. Install each gage cock on a nipple of sufficient length so that the cock handle will be free of the pipe insulation. Position each cock so that a 41/2" diameter dial gage may be easily read and screwed into and out of the cock.

D. On pumps use a single pressure gage connected by ball valves and metal tubing to the inlet and discharge flanges as well as the suction diffuser inlet flange, if applicable.

E. Install gage cocks at each pump as close to pump suction and discharge connections as practicable. Use any gage connections provided in the pump casing.

3.3 GAGE APPLICATIONS

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

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

C. Furnish and install calibrated pressure gauges at each location indicated on the Drawings, specified elsewhere herein, and/or as a standard.

3.4 INSTALLATIONS

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

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

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

D. Install ball-valve and snubber or syphon fitting in piping for each pressure gage.

E. Install test plugs in tees in piping.

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

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

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

**END OF SECTION**

# SECTION 22 05 23

# GENERAL-DUTY VALVES FOR PLUMBING PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following general-duty valves:

1. Copper-alloy ball valves.
2. Ferrous-alloy ball valves.
3. Ductile-iron butterfly valves.
4. High-pressure butterfly valves.
5. Bronze check valves.
6. Cast-iron swing check valves.
7. Spring-loaded, lift-disc check valves.
8. Chainwheel actuators.

B. Related Sections include the following:

1. Division 21 fire-suppression piping and fire pump Sections for fire-protection valves.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and charts.
3. Division 22 piping Sections for specialty valves applicable to those Sections only.
4. Division 23 "Facility Natural Gas Piping" for natural gas valves.

1.2 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.

5. TFE: Tetrafluoroethylene plastic.

6. NRS: Nonrising stem.

7. OS&Y: Outside screw and yoke.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated. Include body the following:

1. Seating, and trim materials

2. Valve design

3. Pressure and temperature classifications

4. End connections

5. Arrangement

6. Dimensions

7. Required clearances.

8. Include list indicating valve and its application by system and size.

9. Include rated capacities.

10. Shipping, installed, and operating weights.

11. Furnished specialties.

12. Accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each valve include operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein. All products to be purchased from Ferguson Enterprises.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

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

D. Bronze valves shall be made with dezincification-resistant materials. All valves shall comply with the current edition of recognized industry standards for design,

materials and testing. These standards include but are not limited to MSS SP-80 and MSS SP-110.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set ball and plug valves open to minimize exposure of functional surfaces.

4. Set butterfly valves closed or slightly open.

5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

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

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

## PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged or grooved ends, unless otherwise indicated.

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

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive: For quarter-turn valves NPS 8 and larger.

3. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.

4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Extended Valve Stems: On insulated valves. Valves shall have 2-inch (50-mm) stem extensions and the following features:

1. Ball Valves: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.

a. NIBCO Nib-seal handle extension

b. Conbraco Industries, Inc.; Apollo Div.

c. Jamesbury, Inc.

d. Kitz Insulated Stem Extension Model #ISE 1 thru 4

e. Milwaukee Valve: The Insulator/MS

2. Butterfly Valves: Shall have extended necks.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.

J. Solder Joint: With sockets according to ASME B16.18.

1. Caution: Use solder with melting point below 840 deg F for check valves; below 421 deg F for ball valves.

K. Threaded: With threads according to ASME B1.20.1.

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

2.2 COPPER-ALLOY BALL VALVES

A. Brass Ball Valves, General: MSS SP-110 and have a brass body complying with ASTM B 283.

B. Bronze Ball Valves, General: MSS SP-110 and have a copper alloy body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder or press connection ends, and blowout-proof stems.

C. Two-Piece, Full-Port, Copper Alloy Ball Valves with Bronze Trim: Chrome-plated bronze ball and bronze stem and; reinforced TFE seats; threaded body packnut

design (no threaded stem designs allowed) with adjustable stem packing, solder or threaded or press connection ends; and 150 psig SWP 600-psigCWP rating.

1. NIBCO Model S-585-80-LF or T-585-80-LF
2. Conbraco Industries, Inc.; Apollo 77CALF
3. Watts Model
4. Milwaukee UPBA450 or UPBA400
5. Hammond UP8311A or UP88301A

D. Two-Piece, Full-Port, Copper-alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, soldered or threaded or press connection ends; 150 psig SWP and 600-psig CWP ratings.

1. NIBCO Model S-585-66-LF or T-585-66-LF
2. Conbraco Industries, Inc.; Apollo 77CALF
3. Watts Model
4. Milwaukee UPBA400S, UPBA450S
5. Hammond UP8303A, UP8313A

E. Three-Piece, Full Port, Copper-alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, stainless nuts and bolts on valve body, soldered or threaded or press connection ends; 150 psig SWP and 600-psig CWP rating.

1. NIBCO Model S-595-Y-66-LF or T-595-Y-66-LF
2. Conbraco Industries, Inc.; Apollo 82LF
3. Milwaukee UPBA350S, UPBA300S
4. Hammond UP8613, UP8603

2.3 BRONZE BUTTERFLY VALVES

A. Bronze Butterfly Valves, General: CTS 2 (DN50) – 8 (DN300),300-psig CWP rating with offset, aluminum-bronze disc and bronze cast body. Bubble tight bi-directional and dead-end service at full rated pressure.

1. Victaulic Company Style 608N.

2.4 DUCTILE or CAST IRON BUTTERFLY VALVES

A. Butterfly Valves, General: MSS SP-67, for bubble-tight shutoff, extended-neck for insulation, disc and lining suitable for potable water, unless otherwise indicated, and with the following features:

1. Full lug, grooved and flanged valves shall be suitable for bi-directional dead end service at full rated pressure without the use or need of a downstream flange. Valves NPS 12 and smaller shall not have exposed stem to disc fasteners and no exterior mounted fasteners to hold the liner.

2. Valve sizes NPS 2 through NPS 6 shall have lever lock operator; valve sizes NPS 8 and larger shall have weatherproof gear operator.

B. Class 150: 175-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one- or two-piece Type 400 series stainless-steel stem, bronze bushing, aluminum-bronze disc, and phenolic-backed EPDM seat (liner) attached to the body.

1. NIBCO Model LD-1000

2. Cooper Cameron Corp. Model NF-*C (238 Series)* 511435-A

3. DeZURIK; SPX Corporation Model BRS *Series* BHP, (*Size),* LD-DI-EPDM-EPDM-BZ-S4-*

4. Conbraco Industries, Inc; Apollo LC-149

5. Milwaukee ML333E

6. Hammond 6411

7. Grinnell

C. Class 200: 200-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one or two-piece Type 400 series stainless-steel stem, copper bushing, fasteners and pins shall not be used to attach stem, to disc, no pins or fasteners in waterway, aluminum-bronze disc, and molded-in EPDM seat (liner).

1. NIBCO Model LD-2000

2. Cooper Cameron Corp. Model NF-C *(221Series*) 511435-*

3. DeZURIK; SPX Corporation Model BRS *(Size)* LD-DI-EPDM-EPDM-BZ-S4-*

4. Conbraco Industries, Inc; Apollo LD-141

5. Milwaukee ML333E

6. Hammond 6411

7. Grinnell

D. Grooved-End, Ferrous-Alloy Butterfly Valves with EPDM-Encapsulated Ductile-Iron Disc or electroless nickel coated ductile iron disc with EPDM seal, Ductile-iron body or stainless steel body with grooved ends, polyamide coating inside and outside or alkyd enamel inside and outside, two-piece Type 416 stainless-steel stem, PTFE bronze sintered on steel bushing or TFE lined fiberglass and brass bushing, fasteners and pins shall not be used to attach stem to disc, no pins or fasteners in waterway, and 300-psig CWP Rating for Valves NPS 2 through NPS 8, 200 psig CWP Rating for Valves NPS 10 through NPS 12.

1. NIBCO Model GD-4765

2. Victaulic Co. of America. Model Vic-300-Master Seal Style 361 or Style 461.

2.5 CARBON STEEL HIGH-PRESSURE BUTTERFLY VALVES

A. High-Pressure Butterfly Valves, General: MSS SP-68 API 609 seat pressure and temperature ratings, ANSI B1634A body pressure and temperature ratings, ANSI B16.5 flange dimensions, ISO 5211, EN 12116 actuator mounting top works, capable of bi-directional dead-end service at full-rated pressure without use of downstream flange, carbon-steel body, offset design, extended-neck for insulation, permanently lubricated 300-series stainless-steel bushings with graphite and modified PTFE seats, graphite packing and gasket, one-piece duplex stainless-steel stem, and stainless-steel disc. Valves NPS 6 and smaller shall have lever-lock operator; valves NPS 8 and larger shall have weatherproof gear operator.

B. Class 150, Full-Lug, 285 psig CWP Rating, High-Pressure Butterfly Valves:

1. NIBCO Model LCS6822

2. Jamesbury, Inc. Model *(Size)* 815L-11-22-36-TT-*

3. WKM Model *(Size)* Model B 113-05-SO1-11-*

4. Conbraco Industries, Inc; Apollo Series 215 HPBFV

5. Milwaukee HP1LCS

6. Hammond HP1LCS

2.6 BRONZE CHECK VALVES

A. Bronze Check Valves, General: MSS SP-80.

B. Class 125, Bronze, Lift Check Valves with TFE Disc: ASTM B-584 bronze body and integral seat with soldered or threaded end connections, and having 250-psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. Kitz Model 836 or 826

3. NIBCO Model S-480-Y-LF or T-480-Y-LF

4. Conbraco Industries, Inc; Apollo Model 61

5. Powell, Wm. Co.

6. Milwaukee UP1548T, UP548T

7. Hammond UP947, UP943

C. Class 125, Bronze, Swing Check Valves with TFE Disc: ASTM B-584 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.

1. NIBCO Model S-413-Y-LF or T-413-Y-LF

2. Conbraco Industries, Inc; Apollo 163S or 163T

3. Powell, Wm. Co.

4. Milwaukee UP1509, UP509

5. Hammond UP912, UP904

D. Class 150, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 300 psig CWP rating.

1. NIBCO Model S-433-Y or T-433-Y

2. Conbraco Industries, Inc; Apollo 164T

3. Powell, Wm. Co.

4. Milwaukee 1510T, 510T

5. Hammond IB945

2.7 IRON SWING CHECK VALVES

A. Iron Swing Check Valves, General: MSS SP-71.

B. Class 125, Gray-Iron, Standard Swing Check Valves: ASTM A-126, Class B cast-iron body and bolted bonnet with flanged end connections; non-asbestos synthetic-fiber gaskets; bronze disc and seat; and having 200 psig CWP rating.

1. NIBCO Model F-918-N

2. Conbraco Industries, Inc; Apollo 910F

3. Powell, Wm. Co.

4. Milwaukee F-2974-M

5. Hammond IR1126-HI

C. Grooved-End, Spring Assisted Check Valves: ASTM A536 Ductile-iron body with grooved ends, stainless steel spring and synthetic seats and having 250-psig CWP Rating.

1. Anvil International, Inc.

2. NIBCO Model G-917-W

3. Victaulic Co. of America

2.8 IRON SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Lift-Disc Check Valves, General: FCI 74-1 and MIL-V-18436F, with spring-loaded, center-guided bronze disc and seat.

B. Class 125, Globe, Flanged Lift-Disc Check Valves: Globe style with cast-iron body and flanged ends, and having 200 psig CWP rating.

1. NIBCO Model F-910-B-LF

2. Milwaukee 1800

3. Hammond IR9354

2.9 CHAINWHEEL ACTUATORS

A. Manufacturers:

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries, Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.

2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. 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.

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

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

E. 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.

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

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball or butterfly valves.

2. Throttling Service: Ball or butterfly valves.

3. Pump Discharge: Spring-loaded, lift-disc check valves.

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

C. Domestic Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, copper alloy.

2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full port, ferrous alloy.

3. Butterfly Valves, NPS 2 to NPS 12 (DN 50 to DN 300): Single-flange, full lug, 200-psig CWP rating, aluminum bronze disc, EPDM liner, ductile iron body.

4. Butterfly Valves, NPS 14 (DN 350) and Larger: Single-flange, full lug, 150-psig CWP rating, aluminum bronze disc, EPDM liner, ductile iron body.

5. High-Pressure Butterfly Valves, NPS 2-1/2 (DN 65) and Smaller: Single-flange full lug, 285 psig (1964 kPa) CWP rating.

6. Grooved-End, Bronze Butterfly Valves, CTS 2 to 8 (DN 50 to DN 300): 300-psig (2070-kPa) CWP rating, EPDM-encapsulated aluminum-bronze or stainless steel disc.

7. Grooved-End, Ductile-Iron Butterfly Valves, NPS 2 to NPS 8: 300-psig CWP rating, EPDM- encapsulated ductile-iron disc.

8. Grooved-End, Ductile-Iron Butterfly Valves, NPS 10 to NPS 12 250 to DN 300): 200-psig CWP rating, EPDM- encapsulated ductile-iron disc.

9. Lift Check Valves, NPS 2 and Smaller: Class 125, bronze with TFE disc.

10. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.

11. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, cast-iron, standard.

12. Grooved-End Swing Check Valves, NPS 2-1/2 and Larger: Grooved-end, ductile-iron, swing check valves.

13. Spring-Loaded, Center-Guided, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Class 125, flanged end, iron.

D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded or press connection ends.

2. For Copper Tubing, NPS 2-1/2: Flanged ends.

3. For Grooved-End, Copper Tubing: Valve ends may be grooved.

## 3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

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

F. Install chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Lift Check Valves: With stem upright and plumb.

3.4 JOINT CONSTRUCTION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 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.

**END OF SECTION**

# SECTION 22 05 29

# HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.
5. Pipe stands.
6. Pipe positioning systems.
7. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 DEFINITIONS

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

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

1.3 PERFORMANCE REQUIREMENTS

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

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

C. Pipe hangers and supports shall conform to the recommendations of ASHRAE, ASPE, ANSI, and MSS, unless otherwise indicated.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.

2. Fiberglass pipe hangers.

3. Thermal-hanger shield inserts.

4. Pipe positioning systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.

2. Metal framing systems. Include Product Data for components.

3. Fiberglass strut systems. Include Product Data for components.

4. Pipe stands. Include Product Data for components.

5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.

2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."

2. AWS D1.2, "Structural Welding Code--Aluminum."

3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

4. ASME Boiler and Pressure Vessel Code: Section IX.

## PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

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

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.

2. Bergen-Power Pipe Supports.

3. B-Line Systems, Inc.; a division of Cooper Industries.

4. Carpenter & Paterson, Inc.

5. Empire Industries, Inc.

6. ERICO/Michigan Hanger Co.

7. Globe Pipe Hanger Products, Inc.

8. Grinnell Corp.

9. GS Metals Corp.

10. National Pipe Hanger Corporation.

11. PHD Manufacturing, Inc.

12. PHS Industries, Inc.

13. Piping Technology & Products, Inc.

14. Tolco Inc.

15. Anvil International

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

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

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

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

B. Available Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.

3. GS Metals Corp.

4. Power-Strut Div.; Tyco International, Ltd.

5. Thomas & Betts Corporation.

6. Tolco Inc.

7. Unistrut Corp.; Tyco International, Ltd.

8. Anvil International

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

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

2.4 CUSHION CLAMPS FOR MEDICAL GAS

A. Clamps for trapeeze style hangers, designed to isolate copper medical gas piping from dissimilar metals.

B. Manufacturers:

1. Tolco Inc.

2. HOLDRITE Corp.; Hubbard Enterprises.

2.5 FASTENER SYSTEMS

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

1. Available Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.

b. Empire Industries, Inc.

c. Hilti, Inc.

d. ITW Ramset/Red Head.

e. MKT Fastening, LLC.

f. Powers Fasteners.

2.6 PIPE STAND FABRICATION

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

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Available Manufacturers:

a. ERICO/Caddy Pyramid

b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

1. Available Manufacturers:

a. MIRO Industries.

b. Portable Pipe Hangers.

c. ERICO/Caddy Pyramid

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Available Manufacturers:

a. ERICO/Caddy Pyramid

b. MIRO Industries.

c. Portable Pipe Hangers.

2. Base: Plastic or Stainless steel.

3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Available Manufacturers:

a. Portable Pipe Hangers.

2. Bases: One or more plastic.

3. Vertical Members: Two or more protective-coated-steel channels.

4. Horizontal Member: Protective-coated-steel channel.

5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

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

1. Available Manufacturers:

a. Pate.

b. Thy Curb.

1) Models:

a) TC-1 for insulated roof decks.

b) TC-2 for un-insulated and existing roof decks.

c) TC-3 for Bulb-T roof decks.

2. Pipe curbs and rails with covers shall be all welded 18 gauge galvanized steel shell and baseplate, wood nailer, and TP-1 Duro EPDM cover or TP-2 pipe cover, as detailed on the drawings, for pipe penetration(s).

2.7 PIPE POSITIONING SYSTEMS

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

B. Manufacturers:

1. C & S Mfg. Corp.

2. HOLDRITE Corp.; Hubbard Enterprises.

3. Samco Stamping, Inc.

2.8 EQUIPMENT SUPPORTS

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

1. Available Manufacturers:

a. Pate.

b. Thy Curb.

1) Models:

a) TEMS-1 for insulated roof decks.

b) TEMS-2 for un-insulated and existing roof decks.

c) TEMS-3 for single-ply roof systems.

2. Equipment supports shall be all welded 18 gauge galvanized steel shell, baseplate and counterflashing with internal bulkhead re-enforcement and wood nailer.

2.9 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.

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

## PART 3 - EXECUTION

3.1 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to proper placement of inserts, anchors and other building structural attachments.

3.2 HANGER AND SUPPORT APPLICATIONS

A. Use only one type hangers and supports, by one manufacturer, for each piping service.

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

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

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

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

F. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing or provide copper-plated hangers and supports for copper piping systems where hangers are in contact with bare pipe.

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

H. Horizontal-Piping Hangers and Supports, Select size of hangers and supports to exactly fit pipe size for bare piping, and around piping insulation with saddle or shield for insulated piping. Unless otherwise indicated and except as specified in piping system Sections, install the following types. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.

10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.

11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.

12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Select size of hanger rod attachments to suit hanger rods. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

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

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.

    b. Medium (MSS Type 32): 1500 lb.

    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

M. Spring Hangers and Supports: Select spring hangers and supports to suit pipe size and loading. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   a. Horizontal (MSS Type 54): Mounted horizontally.

   b. Vertical (MSS Type 55): Mounted vertically.

   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

3.3 MEDICAL GAS HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Use cushion clamps on all medical gas piping.

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.

2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4: 5 feet with 3/8-inch rod.

2. NPS 3/8 and NPS 1/2: 6 feet with 3/8-inch rod.

3. NPS 3/4: 7 feet with 3/8-inch rod.

4. NPS 1: 8 feet with 3/8-inch rod.

5. NPS 1-1/4: 9 feet with 3/8-inch rod.

6. NPS 1-1/2 and larger: 10 feet with 3/8-inch rod.

J. Install supports for vertical copper tubing every 15 feet.

## 3.4 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-69. Install hangers, supports, clamps, and attachments as required by the following table to properly support piping from building structure.

| Pipe Size (in) | Max. Hanger Spacing (ft) | Min. Rod Size (in) |
|---|---|---|
| 1/2 | 6 | 3/8 |
| 3/4 | 6 | 3/8 |
| 1 | 6 | 3/8 |
| 1-1/4 | 6 | 3/8 |
| 1-1/2 | 6 | 3/8 |
| 2 | 10 | 3/8 |
| 2-1/2 | 10 | 1/2 |
| 3 | 10 | 1/2 |
| 3-1/2 | 10 | 5/8 |
| 4 | 10 | 5/8 |
| 5 | 10 | 5/8 |
| 6 | 10 | 3/4 |
| 8 | 10 | 7/8 |
| 10 | 10 | 7/8 |
| 12 | 10 | 7/8 |
| 14 | 10 | 1 |
| 16 | 10 | 1-1/8 |
| 18 | 10 | 1-1/4 |
| 20 | 10 | 1-1/4 |
| 24 | 10 | 1-1/4 |

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-69. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

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

E. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

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

H. Install hangers and supports complete with necessary 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 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 so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

O. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

   c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

5. Pipes NPS 8 and Larger: Include wood inserts.

6. Insert Material: Length at least as long as protective shield.

7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.5 EQUIPMENT SUPPORTS

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

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

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

## 3.6 METAL FABRICATIONS

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

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.7 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 inch

3.8 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections**.**

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

**END OF SECTION**

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# SECTION 22 05 48

# VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Delegated Design requirements for system design.
2. Isolation pads.
3. Freestanding and restrained spring isolators.
4. Elastomeric hangers.
5. Spring hangers.
6. Spring hangers with vertical-limit stops.
7. Pipe riser resilient supports.
8. Resilient pipe guides.
9. Restraining braces and cables.
10. Steel and inertia, vibration isolation equipment bases.

B. Related Sections include the following:

1. Division 22 Section "Common Work Results for Plumbing" for description of concrete bases used as vibration isolation.
2. Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for installation locations of pipe saddles at pipe hangers.

1.2 DEFINITIONS

A. IBC: International Building Code.

1.3 PERFORMANCE REQUIREMENTS

1.4 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 22 Section "Common Work Results for Plumbing" for products specified under PART 2 – PRODUCTS.

B. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

    a. Annotate to indicate application of each product submitted and compliance with requirements.

2. Delegated-Design Submittal: For vibration isolation details indicated to comply with performance requirements and design criteria, Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, forces required to select vibration isolators, restraints, and for designing vibration isolation bases.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

4. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

5. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

6. Field-fabricated supports.

7. Restraint Details:

    a. Design Analysis: To support selection and arrangement of restraints. Include calculations of combined tensile and shear loads.

    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings Indicate association with vibration isolation devices.

C. Welding certificates.

D. Common Requirements For Qualification Data:

E. Qualification Data: For professional engineer.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

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

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

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Vibration Isolation and Control

1. Amber/Booth Company, Inc.

2. Hyspan

3. Kinetics Noise Control.

4. Korfund Company.

5. Mason Industries.

6. Vibro-Acoustics.

2.2 VIBRATION ISOLATORS

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

1. Resilient Material: Oil- and water-resistant neoprene.

B. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: Minimum Kx/Ky (horizontal to vertical spring rate) of 1.0.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: Minimum Kx/Ky (horizontal to vertical spring rate) of 1.0.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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

E. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: Minimum Kx/Ky (horizontal to vertical spring rate) of 1.0.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

F. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: Minimum Kx/Ky (horizontal to vertical spring rate) of 1.0.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

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

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

2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Housekeeping Pads: 4" or 6" tall with 1" chamfer on all top edges.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

b. The weight of each inertial block shall not be less than 150% of supported equipment.

c. Extend block minimum 4" beyond equipment base.

d. Chamfer edges minimum 1".

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 SEISMIC-RESTRAINT DEVICES

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

## PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 APPLICATIONS

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

B. Install hanger rod stiffeners to prevent buckling of hanger rods due to seismic forces.

C. Base: None.

1. Suspended Equipment:

a. Suspended Expansion Tanks.

b. Domestic hot water circ. Pumps.

c. Piping in Mechanical Rooms.

2. Isolator: Spring hanger with 2" deflection.

D. Base: Reinforced Concrete Inertia Block

1. Equipment: Pumping Systems

a. Fire.

b. Domestic water.

2. Isolator: Freestanding, open spring type with 1.5" deflection.

E. Base: 4" Housekeeping Pad on Slab on Grade

1. Equipment:

a. Floor mounted Reciprocating Air Compressors.

b. Floor mounted Rotary, Centrifugal, Scroll, and Screw Air Compressors.

c. Floor mounted Medical Vacuum producers.

2. Isolator: 40 durometer elastomeric pad.

F. Base: 4" Housekeeping Pad on Elevated Slab

1. Equipment:

a. Floor mounted Reciprocating Air Compressors.

b. Floor mounted Rotary, Centrifugal, Scroll, and Screw Air Compressors.

2. Isolator:

a. Reciprocating Air Compressor: restrained, open spring type with 2" deflection.

b. Floor mounted Rotary, Centrifugal, Scroll, and Screw Air Compressors: restrained, open spring type with 1" deflection.

c. Floor mounted Medical Vacuum producers: restrained, open spring type with 1" deflection.

G. Miscellaneous Systems

1. Jockey Pump

a. Base: 6" housekeeping pad.

b. Isolator: None.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

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

B. Install spring isolators for the closest three hangers for all piping attached to rotating equipment.

C. Equipment Restraints:

1. Install snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

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

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

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

H. Strength of Support Assemblies: Select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

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

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

6. Measure isolator restraint clearance.

7. Measure isolator deflection.

8. Verify snubber minimum clearances.

9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

E. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

F. Prepare a report that identifies unit components and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

3.5 ADJUSTING

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

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

C. Adjust active height of sprint isolators.

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

**END OF SECTION**

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# SECTION 22 05 53

# IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.2 RELATED SECTIONS

A. Division 09, Section "High-Performance Coatings" for painting of systems.

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 CLOSEOUT SUBMITTALS

A. Valve Tag directory.

1.5 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. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, laminated phenolic with a black surface and white substrate for mechanical engraving, 1/16 inch Minimum thick, and having predrilled holes for attachment hardware and beveled edges.

2. Letter Color: White

3. Background Color: Black

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

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

6. Minimum Letter Size: 1/2 inch. 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.

B. Label Content: Include equipment's Drawing designation or unique equipment number, as directed by the owner. Secondary lettering shall indicate date of installation.

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

D. Punched plastic tape for labels is not acceptable.

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: White

C. Background Color: Red

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

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

F. Minimum Letter Size: 1 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Labels shall conform to ANSI A13.1 and the following table:

| Outside Diameter of Pipe of Covering | Height of Letters |
|---|---|
| ¾" to 1-1/4" | ½" |
| 1-1/2" to 2" | ¾" |
| 2-1/2" to 6" | 1-1/4" |
| 8" to 10" | 2-1/2" |
| Over 10" | 3-1/2" |

B. Available Manufacturers: Seton, Brady, or Westline.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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.

2.4 VALVE TAGS

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

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link and S-hook or beaded chain

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.

2. Fasteners: Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

4. Color: Yellow background with black lettering.

## PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding:

1. Painting of piping is specified in Division 09 Section "High-Performance Coatings."

2. Provide color coding of all pipe services, either paint or PVC wrap, in the following:

a. Boiler Rooms

b. Central Plants / Power Houses

c. Mechanical Rooms

d. Where uninsulated and routed exterior to the building

3. All piping, except for medical gas, shall be painted in exposed areas and in unconditioned areas such as loading docks, parking garages, canopies, and exterior soffits.

4. Use paint with stencils to neatly identify piping and flow direction. Piping shall be stenciled or labeled at 20-foot intervals and at least once in each separate space through which the pipe passes.

5. Color-coded plastic wrap-around labels are an acceptable alternative to painting on insulated pipe. Plastic labels shall only be applied in accordance with code-limitations for smoke developed and flame spread ratings. PVC labels shall only be applied by permission of AHJ.

6. Color code piping in accordance with current facility standard. Where no standard exists for color-coding, provide in accordance with Piping Color Table below:

| HCA Piping Color Table | |
|---|---|
| Piping | Color Description |
| Domestic Water | Blue |

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 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. In no case shall an exposed line enter or leave a room without being identified.

8. Secure identification markers to piping by firmly pressing markers in place, following removal of protective covering. Additionally secure by banding ends of markers in place using 1/2 inch wide aluminum bands of the type normally used to secure insulation in place.

C. Pipe Label Color Schedule: CORDINATE WITH OWNER

1. Domestic Water Piping:

a. Background Color: Blue.

b. Letter Color: White.

2. Sanitary Waste and Storm Drainage Piping:

a. Background Color: Green.

b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems except:

1. Check valves.

2. Valves within factory-fabricated equipment.

3. Shutoff valves directly adjacent to equipment

4. Faucets.

5. Convenience and lawn-watering hose connections.

6. Rough-in connections to end-use fixtures and units.

B. Emergency shut-off valves: Provide permanent equipment label with minimum 1" high lettering. These valves include valves 2" and larger for the following services:

1. Domestic cold water.

2. Domestic hot water.

C. List tagged valves in a valve schedule and provide to Owner with floor plans indicating location.

3.5 WARNING-TAG INSTALLATION

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

3.6 CEILING MARKERS

A. Install labels affixed to the ceiling grid closest to the device to aid in locating components above ceilings.

B. Use color scheme, label style, label material, and lettering as required by Owner's campus standard.

C. Components to be marked:

1. Manual valves

2. Emergency valves.

3. Natural gas.

**END OF SECTION**

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# SECTION 22 07 00

# PLUMBING INSULATION

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:

a. Calcium silicate.

b. Cellular glass.

c. Fiberglass.

d. Flexible elastomeric.

2. Factory-applied jackets.

3. Field-applied cloths.

4. Field-applied jackets.

5. Adhesives.

6. Mastics.

7. Sealants.

8. Tapes.

9. Securements.

10. Thermal Hanger-Shield Inserts

1.2 ACTION SUBMITTALS

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

B. Calculations: For insulation submitted outside of the conductivity range per the "Minimum Pipe Insulation Thickness" Table for the application listed, submit thickness calculations.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail insulation application at pipe expansion joints for each type of insulation.

4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

5. Detail removable insulation at piping specialties, equipment connections, and access panels.

6. Detail application of field-applied jackets.

7. Detail application at linkages of control devices.

8. Detail field application for each equipment type.

1.3 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.

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

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

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

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

## PART 2 - PRODUCTS

2.1 Manufacturers:

A. Fiberglass

1. Johns-Manville.
2. K-Flex.
3. Knauf Fiberglass.
4. Manson (Certain Teed).
5. Owens-Corning.
6. Pittsburg-Corning.

B. Flexible Elastomeric

1. Aeroflex / Aerocel EPDM
2. Armacell / Armaflex

3. RBX Industries / Rubatex

2.2 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. 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. Block Insulation: ASTM C 552, Type I.

2. Special-Shaped Insulation: ASTM C 552, Type III.

3. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.

4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Fiberglass

1. Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

2. Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density.

3. Duct liner, flexible glass fiber; ASTM C1071; Type II, 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; coating air side to be black, unless otherwise indicated, and rated for 4,000 feet per minute air velocity. The airstream surface must be protected with a durable polyacrylate copolymer emulsion, or approved equal, specifically formulated to:

   a. Not support the growth of fungus or bacteria, when tested in accordance with the test method for fungi resistance in ASTM D 5590 with "0" growth rating.

   b. Act as a fungicidal protective coating: water based, VOC < 50 g/l. Fungicidal coating must be EPA registered for use in HVAC duct systems.

2.3 ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide insulation adhesive and jacket manufacturer shall provide jacket adhesive.

B. 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.

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

D. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

E. 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.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide mastics.

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, 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, 59 percent by volume and 71 percent by weight.

4. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.

2. Service Temperature Range: Minus 20 to plus 200 deg F.

3. Solids Content: 63 percent by volume and 73 percent by weight.

E. Color: White.

2.5 SEALANTS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide sealants

B. Joint Sealants for Cellular-Glass Products:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Permanently flexible, elastomeric sealant.

3. Service Temperature Range: Minus 100 to plus 300 deg F.

4. Color: White or gray.

C. 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.

D. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire- and water-resistant, flexible, elastomeric sealant.

3. Service Temperature Range: Minus 40 to plus 250 deg F.

4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

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 Jackets

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

b. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

c. for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

d. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products, Division of ITW; Metal Jacketing Systems.

b. PABCO Metals Corporation; Surefit.

c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

a. Factory cut and rolled to size.

b. Finish and thickness are indicated in field-applied jacket schedules.

c. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.

2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

3) Tee covers.

4) Flange and union covers.

5) End caps.

6) Beveled collars.

7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Avery Dennison Corporation, Specialty Tapes Division.
2. Compac Corp.
3. Ideal Tape Co., Inc., an American Biltrite Company.
4. Venture Tape.
5. Dow Chemical Company (The).

B. 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.

C. 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.

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.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products; Bands.

b. PABCO Metals Corporation; Bands.

c. RPR Products, Inc.; Bands.

2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

2.11 PIPE INSULATION HANGER SHIELDS:

A. Provide shields for hangers on all insulated pipe.

B. Insulation and shields shall consist of a 180 degree galvanized sheet steel shield. Shield lengths and minimum sheet metal gauges shall be as directed below:

| PIPE SIZE | SHIELD LENGTH | MINIMUM GAUGE |
|---|---|---|
| 1/2" to 8" | 12" | 16 |
| 10" & Larger | 22" | 16 |

C. Shields shall be Model CS-CW, except for pipe roller applications and where pipe hanger spacing exceeds 10 feet, then provide Model CSX-CW.

D. At the Contractor's option, shop-fabricated galvanized metal shields may be provided based on approved shop drawings. Length and gauge of sheet metal shall be as specified above.

2.12 PREMANUFACTURED COVERS

A. Preformed manufactured PVC fitting covers with rigid one piece (half-shell) preformed rigid insulation.

## PART 3 - EXECUTION

3.1 GENERAL

A. Materials shall be applied by a qualified insulation applicator/workman skilled in this trade. Insulation shall be installed in accordance with the manufacturers written instructions and in accordance with recognized industry standards. Mechanical fasteners shall be used whenever possible to assure permanent construction. Unsightly work shall be cause for rejection.

B. Materials shall be applied only after surfaces have been tested and thoroughly cleaned of all mill scale, grease and dirt.

C. Non-compressible insulation material shall be installed at hanger supports on cold piping to prevent damage to insulation and vapor barrier. All wet pipe insulation shall be replaced.

D. Insulation of cold surfaces shall be vapor-sealed to prevent condensation.

E. Minimum thickness of insulation shall be as scheduled.

F. Install Pipe Insulation Hanger Shields.

G. Where piping system insulation is specified, cover valves, strainers, unions, flanges, and fittings. Refer to Preformed fitting and valve covers.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, there shall be no exceptions.

3.2 APPLICATION TYPES

A. Equipment

1. E1: Cut insulation to fit contour of equipment, and secure by means of bands or adhesives as required for each individual piece of equipment. Provide vapor barrier and finish as required for each specific application. Provide new cold surfaces of pumps with accessible boxes that easily separate coincidental with parting line of evaporator heads and pump casings. Resulting insulation joints shall be covered with a self-sealing, vapor-barrier tape. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

B. Piping

1. P1: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Use of double tape self-sealing adhesives systems will negate requirements for staples.

2. P2: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

3. P3: Same as P2, except install insulation over heat trace tape. Finish with metal jacket.

3.3 INSULATION SCHEDULE KEYS

**Insulation Types Key**

| | Type | Maximum K Factor @ 75°F | Temp. Limit °F | Density Lb. Per Cubic Foot | Federal Spec. Compliance |
|---|---|---|---|---|---|
| 1. | Calcium Silicate | 0.38 | 1200 | 14 | HH-I-523C |
| 2. | Fiberglass (Rigid) | 0.23 | 450 | 3 | ASTM C 547 Type 1 |
| 3. | Foamed Glass (Cellular) | 0.36 | 850 | 9 | HH-I-1751/3A |
| 4. | Foamed Plastic (Flexible) | 0.25 | 220 | 5 | HH-I-573 |
| 5. | Insulating Cement | 0.7 | 1700 | | SS-C-160 |

**Finishes Key**

| | |
|---|---|
| F1. | 8-ounce glass cloth |
| F2. | Insulation cement |
| F3. | 0.016 aluminum, plain, up through 12" pipe size; 0.016 aluminum, corrugated, for pipe sizes 14" and larger |
| F4. | White all-service jacket (vapor barrier) with self-sealing lap, or taped joints |
| F5. | Two coats vinyl lacquer type white paint |

3.4 EQUIPMENT AND PIPING INSULATION SCHEDULES

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following unless there is a potential for personnel injury.

1. Drainage piping located in crawl spaces.

2. Underground piping.

3. Chrome-plated pipes and fittings.

C. Fitting and Valve Covers:

1. Fitting covers shall be of preformed PVC for indoor service and metal for outdoor service.

2. Insulation material shall be rigid and of the same or greater material type and thickness, density and conductivity as the adjoining pipe. Blanket inserts will not be allowed.

3. Field fabricated fitting covers of same or similar material as pipe covering with preformed rigid inserts as specified in paragraph 1 above.

D. Exposed piping for ADA compliant lavatories shall be provided with premanufactured covers complying with ASTM E-84 for P-traps, waste piping and angle stop valves.

3.5 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water Indoors:

1. Insulation Material: Rigid Fiberglass 1/2 inch thick.

2. Application Type: P2.

3. Finish: F4

B. Domestic Cold Water Outdoors:

1. Insulation Material: or Cellular Glass, with mitered section fittings only and field applied ASJ.

2. Application Type: P2.

3. Finish: F4&F3

C. Domestic Hot and Recirculated Hot Water:

1. Insulation Material: Rigid Fiberglass (refer to Note 1).

2. Application Type: P2.

3. Finish: F4

D. Domestic Hot and Recirculated Hot Water Outdoors:

1. Insulation Material: or Cellular Glass, with mitered section fittings only and field applied ASJ.

2. Application Type: P2.

3. Finish: F4&F3

E. Storm water and Overflow (Drain Bodies and Horizontal piping within building):

1. Insulation Material: Rigid Fiberglass 1 inch Thick.

2. Application Type: P2.

3. Finish: F4.

F. Waste piping conveying cooling coil condensate and waste from chilled drinking water fountains (First 10 feet from receptor):

1. Insulation Material: Rigid Fiberglass 1 inch Thick.

2. Application Type: P2.

3. Finish: F4.

G. Medical Vacuum Pump exhaust piping:

1. Insulation Material: Calcium Silicate 2 inch Thick.

2. Application Type: P1.

3. Finish: F2.

H. Domestic water storage tank (indoor):

1. Insulation Material: Rigid Fiberglass 1-1/2 inch Thick.

2. Application Type: E1.

3. Finish: F2 & F1.

I. Domestic water pumps:

1. Insulation Material:

a. Rigid Fiberglass 2" Thick

b. Foam Glass 2" Thick

c. Foam Plastic 2" Thick

2. Application Type: E1.

3. Finish: F2 & F1.

* Provide insulation where piping is heat traced.

** Refer to insulation types and finishes keys.

*** Table does not apply to factory insulated equipment

Note 1 – See "Domestic Hot Water Pipe Insulation Thickness" table below.

| DOMESTIC HOT WATER PIPE INSULATION THICKNESS | | | | |
|---|---|---|---|---|
| SUPPLY WATER TEMP °F | NON-CIRCULATING RUNOUTS UP TO 1" | CIRCULATING MAINS AND BRANCHES | | |
| | | UP TO 1 1/4" | 1 1/2" & 2" | OVER 2" |
| 170-180 | 1 1/2" | 1 1/2" | 2" | 2" |
| 140-160 | 1 1/2" | 1 1/2" | 2" | 2" |
| 100-130 | 1" | 1" | 1 1/2" | 1 1/2" |

**Note:**

1. The above table is only applicable to insulations in the conductivity range of 0.23 to 0.25. For insulation outside these conductivity ranges, the minimum thickness (T) shall be determined by the following calculation and the calculation submitted for approval:

   $T=r\{(1+t/r)^{K/k}-1\}$

   where T = Thickness

   $r$ = Actual outside radius of pipe (in.)

   $t$ = Insulation thickness per the above table

   K = Conductivity of alternate material

   k = Upper value of the Conductivity Range per the above table

3.6 IDENTIFICATION

A. Paint piping insulation as specified in Division 22 Section "Identification for Plumbing Piping and Equipment".

**END OF SECTION**

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# SECTION 22 11 16

# DOMESTIC WATER PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.

2. Encasement for piping.

B. Related Section:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.

2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

3. Division 22 Section "Common work results for Plumbing" for Pressure-Seal installer requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with 80 psig, unless otherwise indicated.

1.3 ACTION SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

1.4 INFORMATIONAL SUBMITTALS

A. Water Sample Reports: Specified in Part 3 "Cleaning" Article.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Provide plumbing fixtures and drains as listed on Drawings and described herein. Fixture numbers are Zurn products. All products to be purchased from Ferguson Enterprises.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Comply with NSF 61 and NSF 372 for potable domestic water piping and components.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Architect, Construction Manager and Owner no fewer than two days in advance of proposed interruption of water service.

2. Do not proceed with interruption of water service without Owner's written permission.

## PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.

2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

B. Copper or Bronze Pressure-Seal Fittings: Press fittings must be approved in advance by HCA Healthcare Capital Deployment construction management.

1. Manufacturers:

a. Viega (ProPress).

2. Housing: Copper

3. Fittings:

a. Bronze, or copper; ASME B16.51, ICC LC 1002, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372.

b. Size ½-inch thru 4-inch for use with ASTM B88 copper tube type K, L, or M and ½-inch up to include 1-1/4-inch annealed copper tube. EPDM sealing element.

c. Size 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element.

4. Tools: Manufacturer's special tools.

5. Minimum 200-psig working-pressure rating at 250 deg F.

6. Smart Connect feature to guarantee identification of unpressed connections during the testing process.

7. Grooved-Joint Copper-Tube Appurtenances:

a. Manufacturers:

1) Anvil International.

2) Shurjoint Piping Products.

3) Victaulic Company.

b. Copper Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.

c. Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include rigid angled bolt pad design, ferrous housing sections, flush-seal grade E or installation-ready grade P gasket (Fluoroelastomer) suitable and NSF 61 and NSF 372 approved for cold and hot water, and bolts and nuts.

C. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.

1. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.

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, unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Sheet or Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness or high-density, cross-laminated PE film of 0.004-inch minimum thickness.

D. Color: Black.

2.5 SPECIALTY VALVES

A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.6 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. Sleeve-Type Transition Coupling: AWWA C219.

1. Manufacturers:

a. Cascade Waterworks Manufacturing.

b. Dresser, Inc.; Dresser Piping Specialties.

c. Ford Meter Box Company, Inc. (The).

d. JCM Industries.

e. Romac Industries, Inc.

f. Smith-Blair, Inc; a Sensus company.

g. Viking Johnson; c/o Mueller Co.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Manufacturers:

a. EPCO Sales, Inc.

b. Hart Industries International, Inc.

c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

d. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

a. Pressure Rating: 150 psig at 180 deg F.

b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Kits:

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

2. Description:

a. Nonconducting materials for field assembly of companion flanges.

b. Pressure Rating: 150 psig.

c. Gasket: Neoprene or phenolic.

d. Bolt Sleeves: Phenolic or polyethylene.

e. Washers: Phenolic with steel backing washers.

D. Dielectric Couplings:

1. Manufacturers:

   a. Calpico, Inc.

   b. Lochinvar Corporation.

2. Description:

   a. Galvanized-steel coupling.

   b. Pressure Rating: 300 psig at 225 deg F.

   c. End Connections: Female threaded.

   d. Lining: Inert and noncorrosive, thermoplastic.

E. Dielectric Nipples:

1. Manufacturers:

   a. Perfection Corporation; a subsidiary of American Meter Company.

   b. Precision Plumbing Products, Inc.

   c. Victaulic Company.

2. Description:

   a. Copper-Silicon nipple complying with ASTM F 1545.

   b. Pressure Rating: 300 psig at 225 deg F.

   c. End Connections: Male threaded or grooved.

## PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31 Section "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 underground ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer and pressure gage inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

F. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

H. 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.

I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

J. Install piping adjacent to equipment and specialties to allow service and maintenance.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

P. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

Q. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Common Work Results for Plumbing."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Common Work Results for Plumbing."

T. Install grooved piping only in accessible spaces and mechanical rooms.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Rigid style coupling housings composed of two halves only shall be used unless a flexible style coupling composed of two halves is required for a design accommodating thermal expansion / contraction, vibration attenuation of equipment, or seismic movement. All grooved components (couplings, fittings, valves, gaskets, and specialties) shall be of one manufacturer. Grooved manufacturer shall provide on-site training for contractor's field personnel by a factory trained representative in the proper use of grooving tools, application of groove, and product installation. Factory trained representative shall periodically visit the job site and inspect installation.

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. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems and provide Dielectric isolator.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.

C. Install hose end drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

D. Install automatic balancing valves in each hot-water circulation return branch. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for automatic balancing valves.

E. Install automatic balancing valves with a strainer upstream and a check valve immediately downstream.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 2 and Larger: Sleeve-type coupling.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings, nipples or unions.

C. Dielectric Fittings for NPS 2-1/2: Use dielectric flange kits.

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

3.8 CONNECTIONS

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

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

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

3.9 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Paint piping insulation as specified in Division 22 Section "Identification for Plumbing Piping and Equipment".

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.

6. Prepare reports for tests and for corrective action required.

D. Domestic water piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.11 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. Remove plugs used during testing of piping and for temporary sealing of piping during installation.

5. Remove and clean strainer screens. Close drain valves and replace drain plugs.

6. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Fill and isolate system according to either of the following:

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. Submit water samples for testing in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

3.13 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service entrance piping, NPS 8 and smaller, shall be the following:

1. Mechanical-joint, ductile-iron pipe; standard-pattern mechanical-joint fittings; and mechanical joints.

D. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:

1. Soft copper tube, ASTM B 88, Type k; No joints below grade.

E. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B 88, Type L ASTM B 88; cast- or wrought- copper solder-joint fittings; and soldered joints.

F. Aboveground domestic water piping, NPS 2 1/2 and larger, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L ASTM B 88; cast- or wrought- copper solder-joint fittings; and soldered or brazed joints.

2. Hard copper tube, ASTM B 88, Type L ASTM B 88; cast- or wrought- copper solder-joint fittings; and brazed joints for 4" and larger.

3. Hard copper tube, ASTM B 88, Type L; grooved-joint copper-tube appurtenances; and grooved joints.

G. Non-Potable-Water Piping: Use same materials as domestic water piping.

3.14 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 valves for piping NPS 2 and smaller. Use butterfly valves with flanged or grooved ends for piping NPS 2-1/2 and larger.

2. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly valves with flanged or grooved ends for piping NPS 2-1/2 and larger.

3. Hot-Water Circulation Piping, Balancing Duty: Automatic 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.

**END OF SECTION**

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# SECTION 22 11 19

# DOMESTIC WATER PIPING SPECIALTIES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Thermostatic mixing valves.
6. Strainers.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water hammer arresters.
11. Air vents.
12. Trap-seal primer valves.
13. Electrical trap-seal primer systems.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Domestic Water Piping" for water meters.
3. Division 22 Section "Common work results for Plumbing" for Pressure-Seal installer requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.3 ACTION SUBMITTALS

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

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

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Provide plumbing fixtures and drains as listed on Drawings and described herein. Fixture numbers are Zurn products. All products to be purchased from Ferguson Enterprises.

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. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.

2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

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

## PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1001.

3. Size: NPS 1/4 to NPS 3, as required to match connected piping.

4. Body: Bronze.

5. Inlet and Outlet Connections: Threaded.

6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group.

2. Standard: ASSE 1011.

3. Body: Brass, nonremovable, with manual drain.

4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.

5. Finish: Chrome or Rough bronze.

C. Pressure Vacuum Breakers:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1020.

3. Operation: Continuous-pressure applications.

4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.

5. Accessories:

a. Valves: Ball type, on inlet.

D. Laboratory-Faucet Vacuum Breakers:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1035.

3. Size: NPS 1/4 or NPS 3/8 matching faucet size.

4. Body: Bronze.

5. End Connections: Threaded.

6. Finish: Chrome plated.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1012.

3. Operation: Continuous-pressure applications.

4. Body: Bronze.

5. End Connections: Union or solder joint.

6. Finish: Rough bronze.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Pressure Regulators:

1. Manufacturers:

a. Conbraco Industries, Inc.

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

c. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1003.

3. Pressure Rating: Initial working pressure of 150 psig.

4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.

5. Valves for Booster Heater Water Supply: Provide integral bypass on PRV serving booster heaters.

6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Control Valves:

1. Manufacturers:

a. Watts Industries, Inc.; Watts ACV.

b. Zurn Plumbing Products Group; Wilkins Div.

c. Victaulic

2. Description: Pilot-operation, diaphragm-type, single-seated main water control valve.

3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.

4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.

a. Pattern: Angle or Globe-valve design.

b. Trim: Stainless steel.

5. End Connections: Threaded for NPS 2 and smaller; flanged or grooved for NPS 2-1/2 and larger.

C. Pressure Reducing Valve Stations:

1. Manufacturers:

a. Victaulic Series 386C or 386D

2. Description: In lieu of a contractor fabricated assembly, the contractor may provide a factory assembled pressure reducing valve (PRV) station consisting of the following components.

a. Victaulic Style 972S-H Watchdog valve combo with a mechanical limit switch for BMS alert.

b. Assembly shall include required Schedule 10S, type 304L, stainless steel pipe conforming to ASTM A312 with Victaulic stainless steel fittings.

c. Victaulic Series 461 butterfly valves (4) for isolation.

d. Wye-pattern strainers upstream of the PRVs, joined with Victaulic installation ready rigid couplings Style 807 or Style 107V with grade P gaskets.

3. PRV Station shall be UL classified to ANSI / NSF – 61 for potable water service and shall be certified to the low lead requirements of NSF – 372.

4. End Connections: Grooved for 1-1/2 and larger.

2.4 BALANCING VALVES

A. Automatic Balancing Valves:

1. Manufacturers:

a. Flow Design, Inc.

b. Griswold Controls

2. Type: Ball valve with two readout ports and stainless steel flow regulating cartridge.

3. Body: Brass.

4. Size: Same as connected piping, but not larger than NPS 2.

5. Pressure Rating: 400-psig minimum CWP.

6. Ball: Chrome-plated brass.

7. Seats and Seals: Replaceable.

8. End Connections: Solder joint, grooved or threaded.

9. Handle: Vinyl-covered steel.

10. Accuracy: Plus or minus 5%

2.5 THERMOSTATIC MIXING VALVES

A. Thermostatic, Water Mixing Valves:

1. Manufacturers:

a. Armstrong International, Inc. (RADA)

b. Leonard Valve Company.

c. Powers; a Watts Industries Co.

d. Symmons Industries, Inc.

2. Standard: ASSE 1017.

3. Pressure Rating: 125 psig.

4. Type: Exposed-mounting, thermostatically controlled water mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded or union inlets and outlet.

7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.

9. Valve Finish: Rough bronze.

10. Piping Finish: Copper.

B. Manifold, Thermostatic, Water-Mixing-Valve Assemblies:

1. Manufacturers:

a. Leonard Valve Company.

b. Powers; a Watts Industries Co.

c. Symmons Industries, Inc.

d. Armstrong International, Inc. (RADA)

2. Description: Factory-fabricated, exposed-mounting, thermostatically controlled, water-mixing-valve assembly in two-valve parallel arrangement.

3. Large-Flow Parallel: Thermostatic water mixing valve and downstream pressure regulator with pressure gages on inlet and outlet.

4. Intermediate-Flow Parallel: Thermostatic water mixing valve and downstream pressure regulator with pressure gages on inlet and outlet.

5. Small-Flow Parallel: Thermostatic water mixing valve.

6. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.

7. Water Pressure Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.

8. Component Pressure Ratings: 125 psig minimum, unless otherwise indicated.

C. Individual-Fixture, Water Tempering Valves:

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

   a. Zurn Industries, LLC.

2. Standard: ASSE 1016 and 1070, thermostatically controlled, water tempering valve.

3. Pressure Rating: 125 psig minimum unless otherwise indicated.

4. Body: Bronze body with corrosion-resistant interior components.

5. Temperature Control: Adjustable.

6. Inlets and Outlet: Threaded.

7. Finish: Rough or chrome-plated bronze.

## 2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.

2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating for NPS 2-1/2 and larger.

3. End Connections: Threaded for NPS 2 and smaller; flanged or grooved for NPS 2-1/2 and larger.

4. Screen: Stainless steel with round perforations, unless otherwise indicated.

5. Perforation Size:

   a. Strainers NPS 2 and Smaller: 0.020 inch.

   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.

   c. Strainers NPS 5 and Larger: 0.10 inch.

6. Drain: Factory-installed, hose-end drain valve.

## 2.7 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for faucets.

2. Body Material: Bronze.

3. Seat: Bronze, replaceable.

4. Supply Connections: NPS 3/4 threaded or solder-joint inlet.

5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.

6. Pressure Rating: 125 psig.

7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.

8. Refer to Plumbing Fixture Schedule on drawings for finishes.

2.8 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers:

a. Zurn Plumbing Products Group.

2. Standard: ASME A112.21.3M for exposed-outlet, self-draining wall hydrants.

3. Pressure Rating: 125 psig.

4. Operation: Loose key.

5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.

6. Inlet: NPS 3/4.

7. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

8. Operating Keys(s): One with each wall hydrant.

9. Refer to Plumbing Fixture Schedule on drawings for finishes.

B. Nonfreeze, Hot- and Cold-Water Wall Hydrants:

1. Manufacturers:

a. Zurn Plumbing Products Group.

2. Standard: ASME A112.21.3M for concealed -outlet, self-draining wall hydrants.

3. Pressure Rating: 125 psig.

4. Operation: Loose key.

5. Casings and Operating Rods: Of length required to match wall thickness. Include wall clamps.

6. Inlets: NPS 3/4 or NPS 1.

7. Outlet: Concealed.

8. Box: Deep, flush mounting with cover.

9. Vacuum Breaker: Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052 and with garden-hose thread complying with ASME B1.20.7 on outlet.

10. Operating Keys(s): One with each wall hydrant.

11. Refer to Plumbing Fixture Schedule on drawings for finishes.

2.9 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.

2. Pressure Rating: 400-psig minimum CWP.

3. Body: Copper alloy.

4. Ball: Chrome-plated brass.

5. Seats and Seals: Replaceable.

6. Handle: Vinyl-covered steel.

7. Inlet: Threaded or solder joint.

8. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.10 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers:

a. PPP Inc.

b. Sioux Chief Manufacturing Company, Inc.

c. Watts Drainage Products Inc.

d. Zurn Plumbing Products Group.

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.

2.11 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.

2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.

3. Float: Replaceable, corrosion-resistant metal.

4. Mechanism and Seat: Stainless steel.

5. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.

2. Pressure Rating: 150-psig minimum pressure rating.

3. Float: Replaceable, corrosion-resistant metal.

4. Mechanism and Seat: Stainless steel.

5. Inlet and Vent Outlet End Connections: Threaded.

2.12 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

1. Manufacturers:

a. PPP Inc.

b. Sioux Chief Manufacturing Company, Inc.

2. Standard: ASSE 1018.

3. Pressure Rating: 125 psig minimum.

4. Body: Bronze.

5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.

6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.

7. Distribution box as required.

8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.13 ELECTRIC TRAP-SEAL PRIMER SYSTEMS

A. Electric Trap-Seal Primer Systems:

1. Manufacturers:

a. PPP Inc.

2. Standard: ASSE 1044,

3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.

4. Cabinet: Surface-mounting steel box with stainless-steel cover.

5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.

6. Vacuum Breaker: ASSE 1001.

7. Number Outlets: as indicated on drawings.

## PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Refer to Division 22 Section "Domestic Water Piping" for piping applications by system.

C. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

2. Do not install bypass piping around backflow preventers.

D. Install water pressure regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

E. Install water control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

F. Install balancing valves in locations where they can easily be adjusted.

G. Install thermostatic mixing valves with check stops or shutoff valves and strainers on inlets and with shutoff valve on outlet.

1. Install thermometers on inlets and outlet and water regulators if specified.

2. Install cabinet-type units recessed in or surface mounted on wall as specified.

H. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

I. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

J. Install water hammer arresters in water piping according to PDI-WH 201 and drawings.

K. Install air vents at high points of water piping. Install drain piping and discharge to floor drain.

L. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

M. Install electric trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

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

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

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.

2. Intermediate atmospheric-vent backflow preventers.

3. Reduced-pressure-principle backflow preventers.

4. Double-check backflow-prevention assemblies.

5. Pressure-reducing valves.

6. Automatic balancing valves.

7. Thermostatic mixing valves.

8. Manifold, thermostatic mixing valve assemblies.

9. Outlet boxes.

10. Supply-type, trap-seal primer valves.

11. Electric trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly and vacuum breaker assembly according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Confirm flow rate and direction of flow for automatic balancing valves.

C. Set field-adjustable temperature set points of thermostatic mixing valves.

**END OF SECTION**

# SECTION 221123

# DOMESTIC WATER PUMPS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic hot-water circulation:

1. Close-coupled, horizontally mounted, in-line centrifugal pumps.

2. Close-coupled, vertically mounted, in-line centrifugal pumps.

B. Related Sections include the following:

1. Division 22 Section "Domestic-Water Packaged Booster Pumps" for booster systems.

1.2 SUBMITTALS

A. Simultaneous Action Submittals: Domestic water pumps Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section "Overcurrent Protective Device Coordination Study." The release of plumbing equipment submittals is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section "Submittal Procedures" to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor's failure to coordinate simultaneous action submittals will not be considered by the Owner.

B. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

C. Shop Drawings:

1. Diagram power, signal, and control wiring.

2. Short-circuit current rating of equipment assembly.

D. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

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

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Pump Manufacturers:

1. Armstrong Pumps Inc.
2. Aurora Pump; Pentair Pump Group (The).
3. Bell & Gossett Domestic Pump; ITT Industries.
4. Grundfos Pumps Corp.
5. Paco Pumps, Inc.
6. Sterling Peerless; Sterling Fluid Systems Group.
7. Taco, Inc.
8. Thrush Company, Inc.
9. Weinman Div.; Crane Pumps & Systems.

2.2 Ratings:

A. Short-Circuit Current: Match rating of overcurrent protective device serving domestic water pumps.

B. Available Short-Circuit Current: As indicated on the Drawings. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

2.3 CLOSE-COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, horizontally mounted, in-line centrifugal pumps as defined in ANSI HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.

1. Pump Construction: All bronze.

a. Casing: Radially split, cast iron, with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.

b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.

c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.

d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.

e. Bearings: Oil-lubricated; bronze-journal or ball type.

2. Shaft Coupling: Rigid type if pump is provided with coupling.

3. Motor: Single speed, with grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

B. Capacities and Characteristics: REFER TO SCHEDULE ON DRAWINGS

2.4 CLOSE-COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, overhung impeller, single-stage, close-coupled, vertically mounted, in-line centrifugal pumps as defined in ANSI HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted vertically.

1. Pump Construction: Bronze fitted.

a. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.

b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.

c. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.

d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.

e. Bearings: Oil-lubricated; bronze-journal or ball type.

2. Shaft Coupling: Rigid type if pump is provided with coupling.

3. Motor: Single speed, with grease-lubricated ball bearings; and directly mounted to pump casing. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Lifting and Supporting Lug: Factory mounted in top of motor enclosure.

B. Capacities and Characteristics: REFER TO SCHEDULE ON DRAWINGS

2.5 CONTROLS

A. Aquastats: Electric; adjustable for control of hot-water circulation pump.

1. Manufacturers:

a. Honeywell International, Inc.

b. Square D.

c. White-Rodgers Div.; Emerson Electric Co.

2. Type: Water-immersion sensor, for installation in hot-water circulation piping.

3. Range: 65 to 200 deg F (18 to 93 deg C).

4. Operation of Pump: On or off.

5. Transformer: Provide if required.

6. Power Requirement: 120 V, ac.

7. Settings: Start pump at 115 deg F (46 deg C) and stop pump at 120 deg F (49 deg C).

2.6 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

1. On-off status of each pump.

2. Alarm status.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with ANSI HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install close-coupled, horizontally mounted, in-line centrifugal pumps with motor and pump shafts horizontal.

E. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Vibration isolation devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

3.3 CONTROL INSTALLATION

A. Install immersion-type aquastats in hot-water return piping.

B. Install timers.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."

1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.

2. Install pressure gages at suction and discharge of pumps. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and gage connectors.

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

E. Connect aquastats and timers to pumps that they control.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Set aquastats and timers for automatic starting and stopping operation of pumps.

5. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

7. Start motor.

8. Open discharge valve slowly.

9. Adjust temperature settings on thermostats.

10. Adjust timer settings.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

**END OF SECTION**

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# SECTION 22 12 23

# FACILITY INDOOR POTABLE-WATER STORAGE TANKS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes potable-water storage tanks and related accessories for indoor installation.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories. Indicate dimensions, wall thickness, insulation, finishes and coatings, required clearances, methods of assembly of components, and piping connections.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer Certificates: Signed by manufacturers certifying that potable-water storage tanks comply with requirements.

B. Source quality-control test reports.

C. Purging and disinfecting reports.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of potable-water storage tanks and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. ASME Compliance for Steel Tanks: Fabricate and label steel, potable-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

C. Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for potable-water storage tanks. Include appropriate NSF marking.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

## PART 2 - PRODUCTS

2.1 STEEL, POTABLE-WATER STORAGE TANKS

A. Manufacturers:

1. Wessels Co.

2. Wendland mfg.

3. Highland Tank

4. Modern Welding Company Inc.

B. Description: Steel, vertical pressure-rated tank with cylindrical sidewalls.

C. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

D. Construction: ASME code, steel, constructed with nontoxic welded joints, for 125-psig working pressure.

E. Manway: Watertight, for tank more than 36 inches in diameter; same pressure rating as tank.

F. Tappings: Factory-fabricated steel, welded to tank before testing and labeling.

1. NPS 2 and Larger: ASME B16.5, flanged.

G. Specialties and Accessories: Include tappings in the tank and the following:

1. Vacuum relief valve.

2. Free air vent with insect screen.

H. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

I. Tank Interior Finish: Materials and thicknesses complying with NSF 61 Annex G barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

1. Coating: Epoxy resin.

J. Exterior Coating: Manufacturer's standard enamel paint.

2.2 SOURCE QUALITY CONTROL

A. Test and inspect potable-water storage tanks according to the following tests and inspections and prepare test reports:

1. Pressure Testing for ASME-Code, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop in

pressure, and check for leaks. Replace tanks that fail test with new tanks, and repeat until test is satisfactory.

## PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases of dimensions indicated for tanks. Refer to Division 22 Section "Common Work Results for Plumbing."

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.2 INSTALLATION

A. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

B. Install the following devices on tanks where indicated:

1. Vacuum relief valves.

2. Tank vents on nonpressure tanks.

3. Connections to accessories.

C. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to potable-water storage tanks to allow service and maintenance.

C. Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

1. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

a. Valves NPS 2 and Smaller: Ball.

b. Valves NPS 2-1/2 and Larger: Butterfly.

c. Drain Valves: NPS 3/4 ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.

2. Water Piping Connections: Make connections to dissimilar metals with dielectric fittings. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

3.4 FIELD QUALITY CONTROL

A. Perform the following final checks before filling:

1. Test operation of tank accessories and devices.

2. Verify that vacuum relief valves are correct size.

a. Manually operate vacuum relief valves.

b. Adjust vacuum settings.

B. Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

3.5 CLEANING

A. Clean and disinfect potable-water storage tanks.

B. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, use procedure described in AWWA C652 or as described below:

1. Purge water storage tanks with potable water.

2. Disinfect tanks by one of the following methods:

a. Fill tanks with water-chlorine solution containing at least 50 ppm of chlorine. Isolate tanks and allow to stand for 24 hours.

b. Fill tanks with water-chlorine solution containing at least 200 ppm of chlorine. Isolate tanks and allow to stand for three hours.

3. Flush tanks, after required standing time, with clean, potable water until chlorine is not present in water coming from tank.

4. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination made by authorities having jurisdiction shows evidence of contamination.

C. Prepare written reports for purging and disinfecting activities.

**END OF SECTION**

# SECTION 22 34 00

# FUEL-FIRED DOMESTIC WATER HEATERS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following fuel-fired water heaters:

1. Condensing type, storage, gas water heaters.

2. Expansion tanks.

3. Water heater accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

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

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of water heater, signed by product manufacturer.

B. Source quality-control test reports.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

D. ASME Compliance:

1. Fabricate and label all commercial storage or finned-tube type water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV or Section IV, sub section HLW.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.7 WARRANTY

A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.

b. Faulty operation of controls.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

d. Consider "rusty water" a failure.

2. Warranty Period(s): From date of Substantial Completion:

a. Gas Water Heaters:

1) Storage Tank: Five years.

2) Controls and Other Components: Five years.

3) Extended five year prorated warranty, ten years total

b. Compression Tanks: Five years.

## PART 2 - PRODUCTS

2.1 GAS WATER HEATERS

A. High-Efficiency, Condensing, Storage type Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

1. Manufacturers:

a. PVI Industries, LLC.

b. Bradford White Corporation.

c. Smith, A. O. Water Products Company.

d. Teledyne Laars

e. Patterson Kelly

2. Description: Manufacturer's proprietary design to provide at least 88 percent thermal efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.

3. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.

a. Fittings: Factory fabricated of materials compatible with tank.

1) NPS 3 and Smaller: Threaded ends according to ASME B1.20.1.

2) NPS 4 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings. Apply interior finish after tank fabrication.

c. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings.

4. Factory-Installed, Storage-Tank Appurtenances:

a. Anode Rod (If Needed): Replaceable magnesium.

b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

c. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.

d. Jacket: Steel with enameled finish.

e. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. and ASME.

5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.

6. Temperature Control: Adjustable thermostat.

7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

8. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.

9. Capacity and Characteristics: REFER TO SCHEDULE ON DRAWINGS

2.2 EXPANSION TANKS

A. Description: Steel, ASME pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

1. Manufacturers:

a. AMTROL Inc.

b. Taco, Inc.

c. Watts Regulator Co.

d. ELBI

2. Construction:

a. Fittings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.

b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics: REFER TO SCHEDULE ON DRAWINGS

2.3 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

E. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Provide dimension that will support bottom of water heater a minimum of 18 inches above the floor.

F. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

G. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2. Provide Heat Traps on all non circulated systems.

2.4 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

## PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.

2. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install gas water heaters according to NFPA 54.

D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

G. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains.

J. Install thermometer on inlet and outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

K. Install pressure gages on inlet and outlet piping of fuel-fired water heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

L. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

M. Fill water heaters with water.

N. Charge expansion tanks with air.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

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

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

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, confirm proper operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections 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 water heaters. Refer to Division 01 Section "Demonstration and Training."

**END OF SECTION**

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# SECTION 23 05 00

# COMMON WORK RESULTS FOR HVAC

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Common terminology and requirements used throughout this Division.

2. Requirements for Acceptance Testing Agency.

3. Requirements for Professional Engineers responsible for Delegated Design.

4. Piping materials and installation instructions common to most piping systems.

5. Transition fittings.

6. Dielectric fittings.

7. Mechanical sleeve seals.

8. Sleeves.

9. Equipment installation requirements common to equipment sections.

10. Concrete bases.

11. Supports and anchorages.

1.2 DEFINITIONS

A. This section includes the following definitions that are common to most Division 23 Specifications.

1. Definitions found within this section, Division 23 "Common Work Results for HVAC," are considered to generally apply to all sections unless otherwise noted.

2. Other sections may increase or decrease the scope and usage of a particular word, phrase, or abbreviation for the section in which it appears.

B. AHJ: Authority Having Jurisdiction. This abbreviation is the general term for all agencies having oversight and/or inspection authority for a scope of work, trade, or system. AHJ includes agencies such as local and state fire marshals, city inspectors, et. al.

C. AHU: Air handling unit. This abbreviation is the general term for systems that filter and/or changes the sensible and/or latent properties of air supplied to a space. Its use is synonymous with RTU, roof top unit, irrespective of a system's physical location.

D. Bound Material: Bound refers to materials permanently bound, as by stitching or glue, or materials securely fastened in their covers by multiple fasteners that penetrate all papers. Ring binders, spiral binders, brads and screw posts are acceptable fasteners. Loose papers clipped together or stapled at one (1) corner are not acceptable.

E. Business Day: Where this Section and other Sections of this Division use the term "Business Day" it shall mean Monday thru Friday, excluding Holidays recognized by Federal, State and Local government.

F. CAV: Constant air volume.

G. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

H. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

I. CPVC: Chlorinated polyvinyl chloride plastic.

J. DDC: Direct-digital controls.

K. ECM: Electrically commutated motor.

L. EPDM: Ethylene propylene diene monomer rubber.

M. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

N. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

O. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

P. FMS: Facility Management System. May be used interchangeably with BAS, Building Automation System.

Q. Furnish: The material, equipment, etc. to be supplied, but not installed by the supplier.

R. Manufacturers:

1. Available Manufacturers: When used, this allows any manufacturer in compliance with the requirements to be submitted and used for the system indicated, pending engineer's approval. The list of manufacturers is intended to illustrate typical providers.

2. Basis-of-Design: The manufacturer indicated as such is required to be furnished. The Owner reserves the right to select additional manufacturers listed and adjust the bid amount up or down as is indicated on the bid form for the selected manufacturer.

3. Manufacturers: When used, restricts the list of acceptable manufacturers to only the entities indicated that comply with the requirements detailed.

    a. Where the product of a single manufacturer is mentioned by trade name or manufacturer's name in this Division, it is the only acceptable manufacturer.

    b. Where two (2) or more manufacturers are named, only those manufacturers will be considered or approved.

S. NBR: Acrylonitrile-butadiene rubber.

T. NRTL: Nationally Recognized Testing Laboratory.

U. PE: Polyethylene plastic.

V. Products and Materials: Components and assemblies for the construction of the systems as indicated in the Documents including, but not limited to pipes, tubes, ducts, and equipment.

W. Products or Materials: See "Products and Materials".

X. Provide: The materials and equipment described shall be furnished, installed and connected under this Division, complete for operation, unless specifically noted to the contrary. Identical to the phrase "furnish and install".

Y. PVC: Polyvinyl chloride plastic.

Z. RTU: Rooftop unit. The abbreviations means packaged, outdoor, central station AHUs. This abbreviation may be used regardless of whether the unit is located on a roof or at grade.

AA. VAV: Variable air volume.

BB. VFD: Variable frequency drive. This may be used interchangeably with VSD (variable speed drive), VSC (variable speed controller), and VFMC (variable frequency motor controller). This technology varies the frequency of the incoming electrical signal to change the speed of driven equipment.

1.3 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items to the Contractor, but in no way relieve him of the responsibility of reading and complying with all relevant parts of the entire Specification.

B. The Contractor shall examine and coordinate with all Contract Drawings and Specifications, and all Addenda issued. Failure to comply shall not relieve them of responsibility. The omission of details of other portions of the Work from this Division shall not be used as a basis for a request for additional compensation.

C. The specific features and details for other portions of the Work related to the construction in progress or to the existing building(s) shall be determined by examination at the site.

1.4 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items to the Contractor, but in no way relieve him of the responsibility of reading and complying with all relevant parts of the entire Specification.

1.5 INNOVATION MEMORANDUMS

A. The Owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.

1. Innovation Memorandum No. 7: All piping, valves, pipe fittings, and related products to be purchased from Ferguson Enterprises. Contact Bettina Dawson, office (615) 316-1920 or email bettina.dawson@ferguson.com. Refer to Division 23 Sections "General Duty Valves for HVAC Piping", "Facility Natural Gas Piping", "Hydronic Piping".

2. Innovation Memorandum No. 7a: Press piping must be approved in advance by HCA Healthcare Capital Deployment construction management. The only manufacturer allowed is Viega. Press fittings are allowed on low pressure steam and condensate heating piping, chilled water and heating hot water piping. Subcontractors will qualify to install Viega fittings by having a minimum of three years of experience, receive Viega-led training on all HCA projects resulting in becoming a certified installer and carry proof of current certification at all times on the job. Viega to provide formal training for all projects and provide record to HCA of the companies/employees trained, focusing heavily on installation and testing procedures outlined in the General Applications document. Ferguson Enterprises, Viega, HCA and the subcontractor will certify the project, keep records of file and align project with HCA project numbers. All pipe fittings and related products to be purchased from Ferguson Enterprises. Contact Bettina Dawson, office (615) 316-1920 or email bettina.dawson@ferguson.com. HCA Construction Manager

to be notified of intent to use ProPress. Refer to Division 23 Section "Hydronic Piping".

3. Innovation Memorandum No. 13: All building automation systems to be purchased from Johnson Controls, Inc. Contact Kevin Tolbert, 507 E. Michigan St, M-30, Milwaukee, WI 53202, office (478) 952-8740, or email BE-HCA@jci.com. Refer to Division 23 Section "Instrumentation and Control for HVAC."

4. Innovation Memorandum No. 25: Project shall comply with 2020 MEP Guidelines.

1.6 ORDINANCES, PERMITS AND CODES

A. It shall be the Contractor's duty to perform the work and provide the materials covered by these Specifications in conformance with all ordinances and regulations of all authorities having jurisdiction.

B. All work herein shall conform to all applicable laws, ordinances, and regulations of the local utility companies.

C. The work shall be in accordance with, but not limited to, the requirements of:

1. National Fire Protection Association

2. Lee's Summit Building Codes

3. Missouri Safety Code

4. Missouri Boiler Code

5. Missouri Department Of State Health Services

D. Codes and standards referred to are minimum standards. Where the requirements of these Specifications or drawings exceed those of the codes and regulations, the drawings, and Specifications govern.

E. The Contractor shall obtain permits, plan checks, connection and specification fees, inspections, and approvals applicable to the Work as required by the regulatory authorities.

F. Fees and costs of any nature whatsoever incidental to permits, inspections, and approvals shall be assumed and paid by the Contractor.

G. The pro-rata costs, if any, for utilities serving this property will be paid for by the Owner and shall not be included as part of this Contract.

1.7 REFERENCE STANDARDS

A. Where differences between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents occur, the most

stringent shall govern. The Contractor shall promptly notify the Owner's Representative in writing of any such difference.

B. Should the Contractor perform any Work that does not comply with local codes, laws and ordinances, industry standards or other governing regulations, the Work shall be corrected on noncompliance deficiencies with the Contractor bearing all costs.

C. In addition to the aforementioned ordinances, industry standards published by the following organizations shall apply:

1. AIA - AMERICAN INSTITUTE OF ARCHITECTS
2. AABC - ASSOCIATED AIR BALANCE COUNCIL
3. AASHO - AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS
4. ACI - AMERICAN CONCRETE INSTITUTE
5. ADC - AIR DIFFUSION COUNCIL
6. AGA - AMERICAN GAS ASSOCIATION
7. AHRI - AIR CONDITIONING HEATING & REFRIGERATION INSTITUTE
8. AISC - AMERICAN INSTITUTE OF STEEL CONSTRUCTION
9. AMCA - AIR MOVING AND CONDITIONING ASSOCIATION
10. ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE
11. API - AMERICAN PETROLEUM INSTITUTE
12. ASCE - AMERICAN SOCIETY OF CIVIL ENGINEERS
13. ASHRAE - AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC.
14. ASME - AMERICAN SOCIETY OF MECHANICAL ENGINEERS
15. ASTM - AMERICAN SOCIETY FOR TESTING AND MATERIALS
16. AWSC - AMERICAN WELDING SOCIETY CODE
17. AWWA - AMERICAN WATER WORKS ASSOCIATION
18. CDA - COPPER DEVELOPMENT ASSOCIATION
19. CISPI - CAST IRON SOIL PIPE INSTITUTE
20. CTI - COOLING TOWER INSTITUTE

21. FGI - FACILITY GUIDELINES INSTITUTE

22. FMG - FACTORY MUTUAL GLOBAL

23. ICC - INTERNATIONAL CODE COUNCIL

24. IRI - INDUSTRIAL RISK INSURERS

25. NBS - NATIONAL BUREAU OF STANDARDS

26. NFPA - NATIONAL FIRE PROTECTION ASSOCIATION

27. PDI - PLUMBING AND DRAINAGE INSTITUTE

28. SMACNA - SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION

29. UL - UNDERWRITER'S LABORATORIES

D. Where the Documents exceed the above requirements, the Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.

1.8 DRAWINGS AND SPECIFICATIONS

A. The inter-relation of the specifications, the drawings, and the schedules are as follows:

1. The specifications provide the written requirements for the quality, standard, nature of the materials, equipment, and construction systems.

2. The drawings establish the quantities, approximate dimensions, details, and location of equipment.

3. The schedules give the capacities, characteristics, and components.

B. For any individual project, if there is conflict between the drawings and or specifications, they are equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements the resolution shall be determined by the Architect.

C. Contractor is responsible to bring any conflicts in drawings and/or specifications to the attention of the Architect, immediately, prior to any work being done.

D. Review all construction details illustrated on the architectural and structural drawings and be guided thereby.

1.9 SUBMITTAL PROCEDURES

A. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Submit Product Data in electronic format. Files shall be provided in Portable Document Format (.pdf).

a. Submit digital copies of Product Data as required under Division 01.

b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique section identification heading for ease of navigation.

2. In addition to digital copies, hardcopies of Product Data may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

3. Product Data shall not consist of manufacturer's catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.

B. Common Requirements for Shop Drawings and Coordination Drawings: Where this Section and other Sections of this Division require Shop Drawings or Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section "Project Management and Coordination". In addition to the requirements of Division 01 comply with the following:

1. Prepare Shop Drawings and Coordination Drawings in accordance with project's approved BIM Management Plan.

2. Prepare Shop Drawings and Coordination Drawings using computerized modeling software compatible with AutoDesk's Revit®, AutoCAD®, or Navisworks®. Drawings files must be composite with multiple distinctive layers for each of the various trades.

3. Shop Drawings and Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale as follows:

a. Sheet Metal and Duct Systems, including all underfloor work: Minimum 1/8-inch equals one foot.

1) Double-line congested areas.

2) Double-line duct widths greater than 24".

3) Double-line main duct runs to and from air handling equipment rooms.

4) Double-line ductwork with widths 36" and greater.

b. Piping and equipment systems for chilled water, condenser water, refrigerant, heating water, steam and other HVAC piping systems: Preferably at 1/4-inch equals one foot and not less than 1/8-inch equals one foot.

1) Double-line congested areas.

c. HVAC Equipment room layouts with actual equipment, piping, and duct: 1/4-inch equals one foot.

d. Mechanical rooms: Minimum 1/4-inch equals one foot.

1) Double-line all systems.

4. Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.

5. Submit Shop Drawings and Coordination Drawings in electronic format. Files shall include both AutoDesk® compatible source files and files printed to Portable Document Format (.pdf).

a. Submit digital copies of Shop Drawings and Coordination Drawings as required under Division 01.

b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique sheet identification number for ease of navigation.

6. In addition to digital copies, hardcopies of Shop Drawings or Coordination Drawings may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

C. Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for "Other Informational Submittals". In addition to the requirements of Division 01 comply with the following:

1. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with "Compliance". Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full

compliance with the item specified and will provide exactly the same with no deviations.

b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.

c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.

d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.

D. Common Requirements for Qualification Data:

1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of registration in the Project location.

2. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; Submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

1.10 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.

2. Mechanical sleeve seals.

3. Escutcheons.

1.11 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:

1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.

2. Reflected Ceiling Plans: ceiling plans, sections, and other necessary details showing dimensioned layouts for equipment located in or on the ceiling plane. Base dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

    a. Suspended ceiling components.

    b. Structural members to which suspension systems for luminaires will be attached.

    c. Perimeter moldings, decorative ceiling elements, and Architectural features.

    d. Luminaires.

    e. HVAC Diffusers, Registers and Grilles.

    f. Speakers.

    g. Sprinklers.

    h. Fire Alarm initiating devices, including but not limited to the following:

        1) Smoke detectors.

        2) Heat detectors.

        3) Flame detectors.

    i. Fire Alarm notification appliances.

    j. Occupancy sensors.

    k. Access panels.

    l. Security cameras and occupancy detectors.

3. HVAC Equipment Room Layouts: Floor plans, elevations, and other necessary details showing dimensioned layouts for spaces containing HVAC equipment. Base fire suppression equipment dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

    a. Equipment layout and relationships between components and adjacent structural and mechanical elements, including piping and ductwork.

b. Equipment room layouts with actual dimensions, working clearances, required access area above and around equipment, and relative heights of piping, main ducts, outside and relief louvers. Provide at least one (1) section through each equipment room showing the same.

c. Location of luminaires, sprinkler piping and heads, ducts, and diffusers.

d. Equipment support locations, type of support, and weight on each support.

e. Location of structural supports for structure-supported piping.

f. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

g. Dimensioned floor drain locations and the equipment each serves.

h. Trench locations and sizes.

i. Catwalk or equipment maintenance platform assemblies.

4. Temperature Control Diagrams with Sequence of Operations on same drawing.

5. Roof layouts.

B. Welding certificates.

C. Additional Copies: Provide one (1) additional copy for information only, to the Owner.

1. Provide submittals related to the following equipment:

a. Instrumentation and Controls

2. Owner's Address:
HCA Engineering and Facility Management Services
One Park Plaza 2-3E
Nashville, TN 37203.

1.12 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01 Section "Product Substitution Procedures".

1. If item of equipment or device offered as Substitution differs in dimension or configuration from that indicated in the Contract Documents, provide, as part of the substitution submittal, a drawing that shows that the equipment or devices proposed for Substitution can be installed in the space available without interfering with other trades or with access requirements for operations and maintenance in the completed project. Drawings shall be of

appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.

2. Where substitute equipment or devices requires different arrangement or connections from that indicated in the Contract Documents, install the equipment or devices to operate properly and in accordance with the requirements of the Contract Documents. Make incidental changes necessary in piping, ductwork or wiring which results from the inclusion of the substitute equipment or device without any additional cost to the Owner. Pay all additional costs incurred by other trades in connection with changes required by the inclusion of the substituted equipment or device in the Work.

3. When submitting a manufacturer that is not the Basis of Design, the Contractor shall provide an itemized list of all deviations from and compliances with the information detailed in both the specification section and schedule. An additional itemized list shall account for scope increase and deductions based on substitutions for the following minimum items:

   a. Electrical panels, distribution, and safeties.

   b. Structural modifications.

   c. Civil modifications.

   d. Plumbing modifications.

   e. Duct and pipe connections or arrangements.

   f. Space heating and cooling requirements.

   g. Exhaust or ventilation modifications.

   h. Seismic restraint modifications.

   i. Vibration isolation requirements.

B. Manufacturers not listed are subject to design Engineer's review and may not be acceptable. The substitute manufacturer shall submit a complete copy of the appropriate technical specification section minimum ten (10) business days prior to bid with each sub-paragraph noted with the comment, "compliance", "deviation", "alternate" or "not applicable" as described above. In the case of non-primary, vendor-supplied items, the name of the sub-vendor supplying said item, including model number, shall be indicated.

C. Where substitute products or materials requiring different arrangement or connections from that indicated are accepted by the Owner's Representative, install the equipment or devices to operate properly and in harmony with the intent of the Documents, making all incidental changes in piping, ductwork, wiring, and any other trade resulting from the substitution without any additional cost to the Owner.

D. The Owner's Representative reserves the right to call for samples of any item of product or material offered in substitution, together with a sample of the specific item when, in their opinion, the quality of the item and/or the appearance is involved, and it is deemed that an evaluation of the item may be better made by visual inspection.

E. When any request for a substitution of a product or material is submitted and rejected, the item named in the Documents shall be furnished. Repetitive submittal of substitutions for the same item will not be considered.

1.13 QUALITY ASSURANCE

A. All Work shall be performed by properly licensed technicians skilled in their respective trades. All materials, equipment and devices shall be installed in accordance with the recommendations of the manufacturer and in the best standard practice to bring about results of a first class condition.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved in the systems they are working on and that certification is current.

D. Electrical Characteristics for HVAC Equipment:

1. Equipment having higher electrical characteristics other than those specified should be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

2. Where variable frequency drives are provided for equipment, whether installed separately or integral to the equipment, the VFDs shall conform to Division 26 Section, "Variable Frequency Motor Controllers".

E. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided on this project shall meet the requirements of the UL standard in every way, and shall be UL listed and labeled.

F. Products and materials shall be of the best quality customarily applied in quality commercial practice, and shall be by reputable manufacturers.

G. Each major component shall bear a nameplate giving the name and address of the manufacturer, and the catalog number or designation of the component.

H. Products and materials provided under this Division of the Specifications shall be essentially the standard item, unless otherwise noted, of the specified manufacturer, or where allowed, an alternate manufacturer.

I. Common Requirements for Independent Testing and Inspecting Agency Qualifications: Where this Section and other Sections of this Division call for an Independent Testing and Inspecting Agency (Testing Agency); the Testing Agency shall comply with the following requirements:

1. Have the experience and capability to conduct the testing indicated,

2. Be a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to the AHJ and the Engineer-of-Record.

3. Meet the following:

a. Be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.

b. Be regularly engaged in the testing of seismic support of HVAC equipment devices, installations, and systems.

c. Use technicians who are regularly employed for testing services.

1.14 DELIVERY, STORAGE, AND HANDLING

A. Deliver products and materials with factory-applied end caps or "heat shrink" wrappings to protect openings. Maintain opening protection through shipping, storage, and handling to prevent damage and the entrance of dirt, debris, and moisture.

B. Store light sensitive products and materials away from and protected against direct sunlight.

C. Support products and materials at all times to prevent sagging and bending.

D. The area provided for product and material storage at the jobsite shall be clean, dry and exposure to dust minimized.

E. Responsibility for the protection of products and materials shall extend to existing equipment, systems, and products and materials. Erect temporary sheltering structures, provide temporary bracing and supports, or cover existing equipment, systems, and products and materials to prevent damage and the entrance of dirt, debris, and moisture.

F. Failure on the part of the Contractor to comply with the above to the satisfaction of the Architect, Engineer, or either's authorized representative shall be sufficient cause for the rejection of products and materials in question.

1.15 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

D. Installation Drawings

1. Prepare special drawings as called for elsewhere herein or directed by the Architect to coordinate this work with the work of other Divisions, to illustrate changes in this work to facilitate its concealment in finished spaces, to avoid obstructions, or to illustrate the installation of a substitute equipment item.

2. Use these drawings in the field for the installation of all systems and components. Unless otherwise directed, do not submit these drawings for review, but provide 3 copies to the Architect for information.

E. ACTION SUBMITTALS

1. Product Data: For the following:

a. Dielectric fittings.

b. Mechanical sleeve seals.

## PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

C. All piping and tubing shall be American manufactured, unless otherwise indicated.

2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

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

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

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

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

2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Innerlynx.

b. Link-Seal by PSI.

c. Metraflex Co.

2. Sealing Elements: EPDM for high temperature applications and NBR for all others unless otherwise indicated, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe. Seal shall be same manufacturer as sleeve.

3. Pressure Plates: Stainless steel. Include two (2) for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

2.5 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, galvanized, plain ends.

2.6 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

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

3. Packaging: Premixed and factory packaged.

## PART 3 - EXECUTION

3.1 SCOPE OF WORK

A. Inspection of Site

1. The accompanying drawings do not indicate existing mechanical installations other than to identify modifications of and extensions thereof. Site visits and installation inspections to ascertain the conditions to be met are included in the scope.

2. Failure to comply with an inspection of the site shall not constitute ground for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work under this Division.

3. Review construction details of the existing portion of the building during the site inspection and include all work required to modify the existing mechanical installations and install new materials, comprising a part of the mechanical installation, within the present structure.

4. Review all construction details of the new portion of the building as illustrated on the architectural and structural drawings and be guided thereby.

B. Products and Materials Description

1. Where two (2) or more units of the same kind or class of a specific item are required, these shall be the products of a single manufacturer; however, the component parts of the item need not be the products of one (1) manufacturer.

2. In describing the various products and materials, in general each item will be described singularly, even though there may be a multiplicity of identical items. Also, where the description is only general in nature, exact sizes, duties, space arrangements, horsepower requirements and other data shall be determined by reference to the Documents.

C. The Work shall include modifications and extensions to existing systems, and the modification of the existing structure as required accommodating the installation of the Work.

D. Refer to other Divisions of the Specifications for related Work.

E. Install, hang, support, etc. all MEP systems and equipment to satisfy all requirements of the applicable seismic zone using performance requirements and design criteria for project site as indicated by Architect.

F. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases "install", "furnish", "furnish and install", or "provide" as described above has been actually included.

G. The Contractor is responsible for all Work of every description in connection with this Division of the Specifications.

H. The Contractor specifically and distinctly assumes all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.

I. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

J. Provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

K. Electrical Installation

1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:

   a. Temperature Control Wiring and Power Wiring provided by controls contractor.

2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.

3. All chilled water, condenser water piping, domestic cold and hot water piping, and wet fire protection system shall be heat traced when routed external to the building or in areas susceptible to freezing conditions.

3.2 Schedule And Sequence Of Work

A. The Contractor shall meet and cooperate with the Owner and Owner's Representative to schedule and sequence Work so as to ensure meeting scheduled completion dates and avoid delaying other portions of the Work. Work requiring special sequencing shall be at no additional cost to the Owner and shall have no impact on the schedule.

B. Work schedules and completion dates as established shall be rigidly adhered to. Cooperate in establishing these schedules and perform the work under this Division at such times as directed so as to ensure meeting scheduled dates and avoid delaying any other Contractor.

C. The facility will continue to be in use throughout the construction period, and the schedule contemplates working in designated areas in the present facility while other adjacent areas are occupied. Execute work in this Division to minimize disturbance to occupants in adjacent areas.

D. When any work affects any services to any occupied area new permanent or temporary services, or a combination of both, shall be installed to enable occupied areas to function properly. Additional valves required shall be installed without added cost to the Owner.

E. Perform no work in the present facility that interferes with normal hours of occupancy, unless special permission is granted by the Owner. Included are operations which would cause objectionable noise or service interruptions. Each discipline shall coordinate their work with the established phases of construction.

F. Any work involving a service suspension shall be scheduled in advance with the Owner.

G. Should it be necessary to perform certain operations on an "overtime" basis in order not to interrupt the normal usage of the facility, include the costs of such overtime without change in the Contract amount.

3.3 TEMPORARY HEATING AND COOLING

A. Provide all temporary heating and cooling equipment for spaces that require continued use.

B. Should the work in the designated areas affect any services to areas that are to remain in use, provide temporary services as required to enable those occupied areas to function properly. Additional valves, ductwork, equipment and piping required shall be installed without added cost to the Owner.

3.4 SALVAGED MATERIALS

A. Reuse no salvaged material except as noted on the Drawings, specified herein, or directed by the Architect. Remove from the premises all present materials falling under this Division, which are removed from the existing building. Upon completion, leave no "dead" line or equipment installed in any portion of the area being remodeled, unless otherwise indicated.

3.5 ACCESS – COMMON REQUIREMENTS

A. Provide an access door in non-lay-in ceilings to maintain and inspect HVAC components. Components include, but are not limited to, the following:

1. Actuators.

2. Control Modules.

3. Filter Boxes.

4. Fire Protectives.

5. Manual balancing dampers.

6. Terminal boxes.

7. Valves.

B. Unless otherwise indicated, access door shall provide a minimum clear opening of 30" x 30".

3.6 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons, after Architect's final approval of finish, for penetrations of walls, ceilings, and floors according to the following:

1. New piping penetrations shall be one-piece escutcheons.

2. Existing piping penetrations shall be two-piece escutcheons.

3. All sleeved penetrations shall be deep-drawn allow flush installation between escutcheon and finished surface.

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

1. Penetration assemblies shall comply with U.L. Fire Resistance Directory requirements for wall penetrations.

2. Cut sleeves to length for mounting flush with both surfaces, unless otherwise indicated.

    a. Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level to prevent water entrance into sleeved hole. Vertical pipe supports must be extended to and be supported by the floor rather than the sleeve.

    b. Provide concrete pipe curb in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level, minimum, in lieu of extended sleeves.

3. Install sleeves in new walls and slabs as new walls and slabs are constructed.

4. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.

    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

        1) Seal space outside of sleeve fittings with grout.

5. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

N. Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter for above ground locations.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter for above ground and all underground locations.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.7 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.8 PIPING CONNECTIONS

A. 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Equipment called for on the plans and not listed herein shall be provided as though it were fully described herein.

B. Equipment called for herein shall be completely provided, whether fully detailed or not on the plans, and/or scheduled.

C. All equipment as indicated on the plans and as described herein shall be installed per manufacturer's recommendations to allow for proper operation and maintenance of the equipment.

D. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

E. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

F. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

G. Where any piece of equipment is too large for ingress through normal building openings, it shall be placed in its containing space before the enclosing structure is completed.

H. Install equipment to allow right of way for piping installed at required slope.

I. Provide a hose bib for maintenance in the following locations:

1. All mechanical rooms, other than elevator equipment rooms.

2. All penthouses with mechanical equipment, excluding elevator penthouses.

3. Where units are installed outside on a roof, provide a wall hydrant within 100 feet.

3.10 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases not less than 4 inches larger in both directions than supported unit.

2. Concrete bases for all other equipment shall be 6 inches tall above finished floor.

3.11 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.12 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.13 INSTALLATION INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.

B. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Architect for transmission to the Owner.

3.14 OPERATION PRIOR TO COMPLETION

A. When any piece of mechanical or electrical equipment is operable and it is to the advantage of the contractor to operate the equipment, he may do so with permission of Owner, providing that he properly supervises the operation, retains full responsibility for the equipment operated, and protects against dirt accumulations during operation. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner or until final acceptance by the Owner.

B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, and properly adjust the operation of the equipment before final acceptance by the Owner.

C. All equipment is to be maintained per the manufacturer's instructions until Owner's maintenance staff is responsible for operation and upkeep.

3.15 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of competent engineers and/or technicians acceptable to the Owner's Representative to instruct other representatives of the Owner in the complete and detailed operation of each item of equipment or device of all the various electrical systems. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results.

B. Upon completion of these instructions, the Contractor shall obtain a letter of release, acknowledged by the Owner or his authorized representative, stating the dates on which the various kinds of instruction were given, and the personnel to whom the instructions were given.

C. The Contractor shall be fully responsible for proper maintenance of equipment and systems until the instructions have been given the Owner's personnel and the letter of release acknowledged.

D. In providing the instructions to the Owner's personnel, the written operating and maintenance manuals shall be followed in all instances, and the Owner's personnel shall be familiarized with such manuals.

E. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturer's operating and maintenance instructions, parts lists (with sources identified), and other data as appropriate for each system.

**END OF SECTION**

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# SECTION 23 05 13

# COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

B. Related Sections include the following:

1. Division 26 Section "Enclosed Controllers".

2. Division 26 Section "Variable Frequency Drives".

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.

2. Torque, speed, and horsepower requirements of the load.

3. Ratings and characteristics of supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

1.3 WARRANTY

A. All inverter-duty motors shall have minimum 5-year warranty.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. MagneTek/Century

B. Lincoln

C. Marathon

D. General Electric

E. Gould

F. Toshiba

G. Baldor

H. Reliance

I. US Motors

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.3 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.4 POLYPHASE MOTORS

A. Description: ¾ hp and larger NEMA MG 1, Design B, medium induction motor, unless otherwise indicated.

B. Efficiency: Provide premium efficiency type for all motors 1 HP and greater and conform to the minimum efficiencies as listed in ASHRAE 90.1-2015.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.

2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.

2. Motors smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

L. Provide shaft grounding rings.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Spike-proof inverter motor such that voltage spikes will not damage motor insulation.

2. No distance restrictions between any inverter and motor.

3. No frequency limitations.

4. Inverter power conditioning equipment shall not be required to protect motor.

C. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

1. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.

2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 SINGLE-PHASE MOTORS

A. Motors less than ¾ hp shall be one of the following to suit starting torque and requirements of specific motor application, unless noted otherwise:

B. Permanent-split capacitor.

1. Split phase.

2. Capacitor start, inductor run.

3. Capacitor start, capacitor run.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

E. Motors 1/20 HP and Smaller: Shaded-pole type.

F. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.7 MOTOR ENCLOSURES

A. Provide motor enclosures according to the following list as a minimum, unless recommended by the manufacturer for the given application or unless indicated otherwise.

1. Indoor Service: ODP type.

2. Outdoor Service: TEFC type.

3. Inside an Air Stream: For fan motors installed in the air stream by the fan manufacturer the motor enclosure shall be TEAO unless indicated otherwise by the manufacturer.

4. Hazardous Service: For NEC hazardous locations motor enclosures shall be rated for the division, class, and group indicated or required.

## PART 3 - EXECUTION

3.1 STARTER AND MOTOR CONTROLS

A. Provide a suitable NEMA rated starter, one per motor, for control of each motor furnished under this Division. All motors 3/4 horsepower and larger require magnetic or electronic starters, no exceptions. All motors of any size that are automatically controlled require "Hand-Auto" or "Hand-off-Auto" magnetic or electronic starters, no exceptions. All magnetic and electronic starters shall have H-O-A switches.

B. Provide each motor that does not require a starter, a manual starting switch with thermal overload protection with identifying nameplate, green pilot light and stainless steel cover plate equal to Westinghouse Type MS. Switches installed on finished walls shall be flush type.

C. Starter shall have overload protection on all phases. This will require three overload relays for three phase motors and one overload relay for one phase/line voltage motor. Provide NEMA 1B control voltage transformer, "on" green pilot light, and 1-normally open and 2-normally closed auxiliary contacts on each starter, unless otherwise noted.

D. Certain starters and motor controls for motors furnished under this Division are scheduled on the Drawings to be elements of motor control centers provided under Division 26. Except for those scheduled starters, provide a suitable starter for control of each motor furnished under this Division.

E. Each starter shall have a capacity rating within the required limits of the motor which it serves; it shall have overload elements selected to provide protection for the motor.

F. Where a combination starter and disconnect switch or starter and circuit breaker in a common enclosure is scheduled, provide auxiliary contacts on the switch or breaker as required to assure that, when the disconnecting means is open, there are no "live" contact points on the starter.

G. Where a holding coil voltage differs from line voltage, install a transformer with secondary fusing in the starter enclosure.

H. Unless otherwise indicated, furnish starters mounted indoors with NEMA Type 1 enclosures; and furnish those exposed to the weather with NEMA Type 3R enclosures.

I. Where starters are not installed in heated and cooled spaces, the heater elements shall be of the ambient temperature-compensated, bimetallic type.

**END OF SECTION**

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# SECTION 23 05 19

# METERS AND GAUGES FOR HVAC PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermometers.

2. Gauges.

3. Test plugs.

B. Related Sections:

1. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.

2. Division 23 Section "Instrumentation and Controls for HVAC-inch

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene propylene diene monomer rubber.

1.3 ACTION SUBMITTALS

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

B. Wiring Diagrams: For power, signal, and control wiring.

C. Shop Drawings: Schedule for thermometers, gauges, and flowmeters indicating manufacturer's number, scale range, and location for each.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of thermometer and gauge signed by product manufacturer.

1.5 CLOSEOUT SUBMITTALS

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

1.6 EXTRA MATERIALS

A. Provide a PT measurement kit with thermometers and gauges chosen to indicate system pressures and temperatures at mid-scale. Provide multiple of each as mid-scale measurement dictates.

## PART 2 - PRODUCTS

2.1 THERMOMETERS

A. Digital Light-Powered Thermometer, Weatherproof NEMA-4X Case, Trerice Model SX9 Solar Therm.

1. Case: Cast-Aluminum, NEMA-4X
2. Range: -40 to 300 degrees F (-40/150 degrees C)
3. Display: 9/16-inch LCD digits
4. Accuracy: 1% of reading or 1 degrees whichever is greater
5. Resolution: 1/10degrees between
6. Lux Rating: 10 Lux (one foot-candle)
7. Update Rate: 10 seconds.
8. Ambient Operating Range: -40 to 140 degrees F (-40 to 60 degrees C)
9. Ambient Temp. Error: None
10. Humidity Maximum: 95%, non condensing.
11. Sensor: Glass passivated thermistor
12. Connector: Adjustable Angle

B. Digital Vari-angle Thermometer, self-powered and within 1% accuracy, Weiss Model DVU.

1. Case: Hi-impact ABS
2. Range: -50 to 300 degrees F (-45/150 degrees C)
3. Display: 1/2-inch LCD digits, wide ambient formula
4. Accuracy: 1% of reading or 1degrees whichever is greater
5. Resolution: 1/10degrees between -19.9/199.9 degrees F (-28/93 degrees C)
6. Recalibration: Internal potentiometer

7. Lux Rating: 10 Lux (one foot-candle)

8. Update Rate: 10 seconds

9. Ambient Operating Range: -30 to 140 degrees F (-35 to 60 degrees C)

10. Ambient Temp. Error: Zero

11. Humidity: 100%

12. Sensor: Glass passivated thermistor

13. Connector: Adjustable Angle

C. Digital Vari-angle Thermometer, self-powered and within 1% accuracy, Weiss Model 5DVU.

1. Case: 5-inch Hermetically Sealed

2. Range: -50 to 300 degrees F (-45/150 degrees C)

3. Display: 1/2-inch LCD digits, wide ambient formula

4. Accuracy: 1% of reading or 1 degrees whichever is greater

5. Resolution: 1/10 degrees between -19.9/199.9 degrees F (-28/93 degrees C)

6. Recalibration: Internal potentiometer

7. Lux Rating: 10 Lux (one foot-candle)

8. Update Rate: 10 seconds

9. Ambient Operating Range: -30/140 degrees F (-35/60 degrees C)

10. Ambient Temp. Error: Zero

11. Sensor: Glass passivated thermistor

12. Connector: Adjustable Angle

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type 304 Stainless Steel fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAUGES

A. Manufacturers:

1. Ernst Gauge Co.
2. Miljoco Corp.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
6. Dwyer Instruments, Inc.

B. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.

1. Case: Liquid-filled type, cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red or Black metal.
7. Window: Glass.
8. Ring: Stainless steel.
9. Accuracy: Grade B, plus or minus 1/2 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 50 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.

4. Movement: Mechanical, with link to pressure element and connection to pointer.

5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

6. Pointer: Red or Black metal.

7. Window: Glass.

8. Ring: Stainless steel.

9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.

10. Vacuum-Pressure Range: 0 to 50 psig of pressure.

11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure-Gauge Fittings:

1. Valves: NPS 1/4 brass or stainless-steel ball type.

2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.

3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.4 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.

2. MG Piping Products Co.

3. National Meter, Inc.

4. Peterson Equipment Co., Inc.

5. Sisco Manufacturing Co.

6. Trerice, H. O. Co.

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

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

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.

## PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install digital thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.

2. Inlet and outlet of each hydronic boiler and chiller.

3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.

4. Inlet and outlet of each hydronic heat exchanger.

B. Indoor thermometers shall be model: DVU.

C. Outdoor thermometer shall be model: 5DVU.

D. Install thermometers in separable sockets at each additional location indicated on the Drawings or specified elsewhere herein, and/or as a standard.

E. Provide the following temperature ranges for thermometers, unless otherwise indicated:

1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions

2. Condenser Water: 0 to 160 deg F, with 2-degree scale divisions.

3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.

4. Steam and Condensate: 50 to 400 deg F, with 5-degree scale divisions.

3.2 GAUGE COCK APPLICATIONS

A. Install test plugs adjacent to all control sensors (except Insertion Type Flow Meters) installed in piping systems.

B. Valved pressure gauge connections shall be installed in each location indicated on the Drawings and/or specified elsewhere herein.

C. Install each gauge cock on a nipple of sufficient length so that the cock handle will be free of the pipe insulation. Position each cock so that a 4-1/2-inch diameter dial gauge may be easily read and screwed into and out of the cock.

D. On pumps use a single pressure gauge connected by ball valves and metal tubing to the inlet and discharge flanges as well as the suction diffuser inlet flange, if applicable.

E. Install gauge cocks at each pump as close to pump suction and discharge connections as practicable. Use any gauge connections provided in the pump casing.

3.3 GAUGE APPLICATIONS

A. Install dry-case-type pressure gauges at the following locations:

1. Discharge of each pressure-reducing valve.

2. At each steam connection to a heat exchanger in the mechanical equipment rooms.

B. Install liquid-filled-case-type pressure gauges at chilled- and condenser-water inlets and outlets of chillers.

C. On pumps use a single pressure gauge connected by ball valves and metal tubing to the inlet and discharge flanges as well as the suction diffuser inlet flange, if applicable.

D. Furnish and install calibrated pressure gauges at each location indicated on the Drawings, specified elsewhere herein, and/or as a standard.

3.4 INSTALLATIONS

A. Install thermometers and adjust vertical and tilted positions.

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

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

D. Install ball-valve and snubber or syphon fitting in piping for each pressure gauge for fluids (except steam).

E. Install needle-valve and siphon fitting in piping for each pressure gauge for steam.

3.5 Install test plugs adjacent to all gauges and control sensors (except insertion type flow meters) installed in piping systems.

3.6 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance for meters, gauges, machines, and equipment. Install test plugs adjacent to the temperature sensing device used for controls for simultaneous reading with test instrument for calibration purposes.

3.7 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

**END OF SECTION**

# SECTION 23 05 23

# GENERAL-DUTY VALVES FOR HVAC PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following general-duty valves:

1. Bronze angle valves.
2. Cast-iron angle valves.
3. Copper-alloy ball valves.
4. Ferrous-alloy ball valves.
5. Ductile-iron butterfly valves.
6. High-pressure butterfly valves.
7. Bronze check valves.
8. Cast-iron swing check valves.
9. Bronze gate valves.
10. Cast-iron gate valves.
11. Bronze globe valves.
12. Cast-iron globe valves.
13. Cast-iron plug valves.
14. Resilient-seated, cast-iron, eccentric plug valves.

B. Related Sections include the following:

1. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and charts.
2. Division 23 Section "Instrumentation and Control for HVAC" for actuators in control valve applications.
3. Division 23 Section "Hydronic Piping" for additional valves and fittings.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

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

C. HPS: High-pressure Steam. Any system pressure above 15 psig is HPS.

D. LPS: Low-pressure Steam. Any system pressure less than or equal to 15 psig is LPS.

E. NRS: Nonrising stem.

F. OS&Y: Outside screw and yoke.

G. PTFE: Polytetrafluoroethylene plastic.

H. Single Flange: Any valve design where lugs are evenly spaced around the circumference of the valve face and attach to adjoining piping using full length bolts.

I. SWP: Steam working pressure.

J. TFE: Tetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated. Include body the following:

1. Seating, and trim materials

2. Valve design

3. Pressure and temperature classifications

4. End connections

5. Arrangement

6. Dimensions

7. Required clearances.

8. Include list indicating valve and its application by system and size.

9. Include rated capacities

10. Shipping, installed, and operating weights

11. Furnished specialties

12. Accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each valve include operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein. All products to be purchased from Ferguson Enterprises

B. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.

C. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

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

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

## PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Copper-alloy Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated. All valves shall comply with recognized industry standards such as MSS SP-80 and SP-110.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

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

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Gear Drive: Enclosed worm gear.

2. Handwheel: For valves other than quarter-turn types.

3. Lever Handle: Clamp lock.

4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Valves in Insulated Piping: Valves shall have 3-inch stem extensions and the following features:

1. Gate Valves: Shall be rising-stem type.

2. Ball Valves: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.

a. Conbraco Industries, Inc.; Apollo Div.

b. Jamesbury, Inc.

c. NIBCO Nib-seal handle extension

d. Watts

3. Butterfly Valves: Shall have extended necks.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.

J. Solder Joint: With sockets according to ASME B16.18.

1. Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

K. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE ANGLE VALVES

A. Bronze Angle Valves, General: MSS SP-80, with silicon bronze stem, non-asbestos packing and malleable-iron handwheel.

B. Class 150, Bronze Angle Valves: ASTM B 62 bronze body with TFE disc, union-ring bonnet, threaded ends, and having 300-psig CWP rating.

1. NIBCO Model T-335-Y

2. Milwaukee

C. Class 300, Bronze Angle Valves with Stainless-Steel Disc: ASTM B 61 bronze body with stainless-steel plug and renewable seat, union-ring bonnet, threaded ends, and having 600-psig CWP rating.

1. NIBCO Model T-376-AP

2. Milwaukee

2.3 CAST-IRON ANGLE VALVES

A. Cast-Iron Angle Valves, General: MSS SP-85, Type II; having ASTM A 126, Class B cast-iron body and bolted bonnet; bronze mounted, non-asbestos packing and gaskets; and flanged-end connections.

B. Class 125, Cast-Iron, Standard Angle Valves: 200-psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-818-B

3. Milwaukee

C. Class 250, Cast-Iron, Stop-Check Angle Valves: Stop-check design with non-asbestos packing and gaskets, and having 500-psig (3450-kPa) CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model NIBCO Model F-869-B

3. Milwaukee

2.4 COPPER ALLOY BALL VALVES

A. Brass Ball Valves, General: MSS SP-110 and have a brass body complying with ASTM B 283.

B. Bronze Ball Valves, General: MSS SP-110 and have a copper alloy body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder ends, and blowout-proof stems.

C. Two-Piece, Full-Port, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design, blow-out proof stems, with adjustable stem packing, soldered or threaded ends; 150 psig SWP and 600-psig CWP ratings.

1. Conbraco Industries, Inc.; Apollo Div.

**2.** NIBCO Model S-585-70-66 or T-585-70-66

3. Milwaukee

4. Watts

D. Two-Piece, Full-Port, 250 psig SWP, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, carbon-filled TFE seats, threaded body packnut design, blow-out proof stems, with adjustable stem packing, threaded ends; 250 psig SWP and 600-psig CWP ratings.

1. Conbraco Industries, Inc.; Apollo Div.

2. NIBCO Model T-585-70-66-ST

3. Milwaukee

4. Watts

E. Three-Piece, Full Port, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, threaded body packnut, blow-out proof stems, with adjustable stem packing, stainless nuts and bolts on valve body, soldered or threaded ends; 150 psig SWP and 600-psig CWP rating.

1. Conbraco Industries, Inc.; Apollo Div.

2. NIBCO Model S-595-Y-66-SS or T-595-Y-66-SS

3. Milwaukee

4. Watts

2.5 FERROUS-ALLOY BALL VALVES

A. Ferrous-Alloy Ball Valves, General: MSS SP-72, with ASTM A-216 Type WCB, carbon-steel body; ASTM A-351, Type CF8M vented stainless-steel ball; and ASTM A-276, Type 316 stainless-steel stem; fire rated according to API 607 (4th edition); and having flanged ends and blowout-proof stem.

B. Class 150, Full-Port, Ferrous-Alloy Ball Valves: Split-body construction, carbon-filled TFE seats; 285 psig CWP rating.

1. Conbraco Industries, Inc.; Apollo Div.

2. NIBCO Model F-515-CS-F-66-FS

3. Milwaukee

4. Watts

C. Class 300, Full-Port, Ferrous-Alloy Ball Valves: Split-body construction, carbon-filled TFE seats; 720 psig CWP rating.

1. Conbraco Industries, Inc.; Apollo Div.

2. NIBCO Model F-535-CS-F-66-FS

3. Milwaukee

4. Watts

2.6 FERROUS-ALLOY BUTTERFLY VALVES

A. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, for bubble-tight shutoff, extended-neck for insulation, disc and lining suitable for potable water, unless otherwise indicated, and with the following features:

1. Full lug, grooved and flanged valves shall be suitable for bi-directional dead end service at full rated pressure without the use or need of a downstream flange. Valves NPS 12 and smaller shall not have exposed stem to disc fasteners and no exterior mounted fasteners to hold the liner.

2. Valve sizes NPS 2 through NPS 6 shall have lever lock operator; valve sizes NPS 8 and larger shall have weatherproof gear operator.

B. Single-Flange, 150-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one- or two-piece Type 416 stainless-steel stem, bronze bushing, aluminum-bronze disc, and phenolic-backed EPDM seat (liner) attached to the body.

1. Centerline

2. Crane

3. NIBCO Model LD-1000-5

C. Single-Flange, 200-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one- or two-piece, Type 410 or 416 stainless-steel stem, copper bushing, fasteners and pins shall not be used to attach stem, to disc, no pins or fasteners in waterway, aluminum-bronze disc, and molded-in EPDM seat (liner).

1. Centerline

2. Crane

3. NIBCO Model LD-2000-3/5

D. Grooved-End, Ferrous-Alloy Butterfly Valves with EPDM-Encapsulated Ductile-Iron Disc: Ductile-iron with grooved or shouldered ends, polyamide coating inside and outside, two-piece Type 416 stainless-steel stem, PTFE bronze sintered on steel bushing, fasteners and pins shall not be used to attach stem to disc, no pins or fasteners in waterway, and 300-psig CWP Rating for Valves NPS 2 through NPS 8, 200 psig CWP Rating for Valves NPS 10 through NPS 12.

1. Victaulic Co. of America.

2.7 HIGH-PRESSURE BUTTERFLY VALVES

A. High-Pressure Butterfly Valves, General: MSS SP-68 API 609 seat pressure and temperature ratings, ANSI B1634A body pressure and temperature ratings, ANSI B16.5 flange dimensions, ISO 5211, EN 12116 actuator mounting top works, capable of bi-directional dead-end service at full-rated pressure without use of downstream flange, carbon-steel body, offset design, extended-neck for insulation, permanently lubricated 300-series stainless-steel bushings with graphite and modified PTFE seats, graphite packing and gasket, one-piece duplex stainless-steel stem, and stainless-steel disc. Maximum steam rating of 50 psig. Valves NPS 6 and smaller shall have lever-lock operator; valves NPS 8 and larger shall have weatherproof gear operator.

B. Single-Flange, Full-Lug, 285 psig CWP Rating, High-Pressure Butterfly Valves:

1. Crane

2. Centerline

3. NIBCO Model LCS6822-3/5

C. Single-Flange, Full-Lug, 720 psig CWP Rating, High-Pressure Butterfly Valves:

1. Crane

2. Centerline

3. NIBCO Model LCS7822-3/5

2.8 BRONZE CHECK VALVES

A. Bronze Check Valves, General: MSS SP-80.

B. Class 125, Bronze, Lift Check Valves with TFE Disc: ASTM B-584 bronze body and integral seat with soldered or threaded end connections, and having 250-psig CWP rating.

1. NIBCO Model S-480-Y or T-480-Y

2. Milwaukee

C. Class 125, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.

1. NIBCO Model S-413-Y or T-413-Y

2. Milwaukee

D. Class 150, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 300 psig CWP rating.

1. NIBCO Model S-433-Y or T-433-Y

2. Milwaukee

E. Class 300, Bronze, Swing Check Valves with Bronze Disc: ASTM B-61 bronze body and seat with regrinding-type bronze disc, Y-pattern design, threaded end connections, and having 600 psig CWP rating.

1. NIBCO Model T-473-B

2. Milwaukee

2.9 IRON SWING CHECK VALVES

A. Iron Swing Check Valves, General: MSS SP-71.

B. Class 125, Gray-Iron, Standard Swing Check Valves: ASTM A-126, Class B cast-iron body and bolted bonnet with flanged end connections; non-asbestos synthetic-fiber gaskets; bronze disc and seat; and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-918-B

3. Milwaukee

C. Class 250, Gray-Iron, Swing Check Valves: ASTM A-126, Class B cast-iron body and bolted bonnet with flanged end connections; non-asbestos synthetic-fiber gaskets; and bronze disc and seat; and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-968-B

3. Milwaukee

D. Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends; nonasbestos, synthetic-fiber gaskets; rubber seats; and having 250-psig CWP Rating.

1. Victaulic Co. of America

2.10 BRONZE GATE VALVES

A. Bronze Gate Valves, General: MSS SP-80, with malleable-iron handwheel.

B. Class 150, Rising-Stem, Union-Ring Bonnet, Bronze Gate Valves: ASTM B-62 bronze body, bonnet, and wedge, copper-silicone bronze stem, union-ring bonnet, soldered or threaded end connections; and having 300 psig CWP rating.

1. NIBCO Model S-134 or T-134

2. Milwaukee

C. Class 300, Rising-Stem, Stainless-Steel Wedge, Bronze Gate Valves: ASTM B-61 bronze body, bonnet and seat, stainless-steel wedge and seat, copper-silicone bronze stem, union-ring bonnet, and threaded end connections; and having 600 psig CWP rating.

1. NIBCO Model T-174-SS

2. Milwaukee

2.11 CAST-IRON GATE VALVES

A. Cast-Iron Gate Valves, General: MSS SP-70, Type I with bolted bonnet, flanged end connections, and non-asbestos packing and gasket.

B. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim, and solid-wedge disc; and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-617-O

3. Milwaukee

C. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim, and solid-wedge disc; and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-667-O

3. Milwaukee

2.12 BRONZE GLOBE VALVES

A. Bronze Globe Valves, General: MSS SP-80, with malleable-iron handwheel.

B. Class 150, TFE Disc, Bronze Globe Valves: ASTM B-62 bronze body, bonnet, and seat, TFE disc, copper-silicone bronze stem, union-ring bonnet, soldered or threaded end connections; and having 300 psig CWP rating.

1. NIBCO Model S-235-Y or T-235-Y

2. Milwaukee

C. Class 300, Stainless-Steel Disc, Bronze Globe Valves: ASTM B-61 bronze body and bonnet, stainless-steel disc and seat, copper-silicone bronze stem, union-ring bonnet, threaded end connections; and having 600 psig CWP rating.

1. NIBCO Model T-276-AP

2. Milwaukee

2.13 CAST-IRON GLOBE VALVES

A. Cast-Iron Globe Valves, General: MSS SP-85 with bolted bonnet, flanged end connections, and non-asbestos packing and gasket.

B. Class 125, Metal Seat, Cast-Iron Globe Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-718-B

3. Milwaukee

C. Class 250, Metal Seat, Cast-Iron Globe Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO Model F-768-B

3. Milwaukee

2.14 CAST-IRON PLUG VALVES

A. Cast-Iron Plug Valves, General: MSS SP-78 and rated for the working pressure of the system it is installed in.

B. Manufacturers:

1. Lubricated-Type, Cast-Iron Plug Valves:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. NIBCO

c. Milwaukee

2. Nonlubricated-Type, Cast-Iron Plug Valves:

a. Crane Co.; Crane Valve Group; Crane Valves.

b. NIBCO

c. Milwaukee

2.15 RESILIENT-SEATED, CAST-IRON, ECCENTRIC PLUG VALVES

A. Manufacturers:

1. Crane Co.; Crane Valve Group; Crane Valves.

2. NIBCO

3. Milwaukee

B. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 2-1/2 and Smaller: Design similar to MSS SP-108, and rated for 175-psig minimum CWP.

C. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 3 and Larger: MSS SP-108, and rated for 175-psig minimum CWP.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

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

B. 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.

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

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

E. 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.

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

3.2 VALVE APPLICATIONS

A. Chilled-Water Piping:

1. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, copper alloy.

2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full -port, ferrous alloy.

3. Butterfly Valves, NPS 2 to NPS 12: Single-flange, full lug, 200-psig CWP rating, bronze disc, EPDM liner, ductile iron.

4. High-Pressure Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, 285 psig CWP rating.

5. Grooved-End, Ductile-Iron Butterfly Valves, NPS 2 to NPS 8 300-psig CWP rating, EPDM- encapsulated ductile-iron disc.

6. Lift Check Valves, NPS 2 and Smaller: Class 125, non-slam type, bronze with TFE disc.

7. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.

8. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, non-slam type, cast-iron, standard.

9. Grooved-End Swing Check Valves, NPS 2-1/2 and Larger: Grooved-end, ductile-iron, swing check valves.

10. Plug Valves, NPS 2 and Larger: Class 125 or 150, lubricated-type, cast iron.

11. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

B. Condenser Water Piping:

1. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, copper alloy.

2. Ball Valves, NPS 2-1/2 and Larger: Class 150**,** full -port, ferrous alloy.

3. Butterfly Valves, NPS 2 to NPS 12 Single-flange, full lug, 200-psig CWP rating, bronze disc, EPDM liner, ductile iron.

4. High-Pressure Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, 285 psig CWP rating.

5. Grooved-End, Ductile-Iron Butterfly Valves, NPS 2 to NPS 8: 300-psig CWP rating, EPDM- encapsulated ductile-iron disc.

6. Lift Check Valves, NPS 2 and Smaller: Class 125, non-slam type, bronze with TFE disc.

7. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.

8. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, non-slam type, cast iron, standard.

9. Grooved-End Swing Check Valves, NPS 2-1/2 and Larger: Grooved-end, ductile-iron, swing check valves.

10. Plug Valves, NPS 2 and Larger: Class 125 or 150, lubricated-type, cast iron.

11. Resilient-Seated, Eccentric Plug Valves, NPS 3 and Larger: 175-psig CWP rating, cast iron.

C. Heating Water Piping:

1. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, copper alloy.

2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full -port, ferrous alloy.

3. Butterfly Valves, NPS 2 to NPS 12 Single-flange, full lug, 200-psig CWP rating, bronze disc, EPDM liner, ductile iron.

4. High-Pressure Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, 285 psig CWP rating.

5. Lift Check Valves, NPS 2 and Smaller: Class 125, bronze with TFE disc.

6. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.

7. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, cast iron, standard.

8. Gate Valves, NPS 2 and Smaller: Class 150, bronze.

9. Gate Valves, NPS 2-1/2 and Larger: Class 125, cast iron.

D. Steam Piping, 0 - 125 psig Operating Pressure:

1. Angle Valves, NPS 2 and Smaller: Class 150, with TFE disc, bronze.

2. Angle Valves, NPS 2-1/2 and Larger: Class 125, cast iron.

3. Ball Valves, NPS 2 and Smaller: Two -piece, full port, stainless-steel trim, bronze.

4. Ball Valves, NPS 2-1/2 and Larger: Class 150, full -port, ferrous alloy.

5. High-Pressure Butterfly Valves, NPS 2-1/2 and Larger: Single-flange 285 psig CWP rating.

6. Swing Check Valves, NPS 2 and Smaller: Class 125, bronze with TFE disc.

7. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, cast-iron, standard.

8. Gate Valves, NPS 2 and Smaller: Class 150, bronze.

9. Gate Valves, NPS 2-1/2 and Larger: Class 125, cast iron.

10. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, TFE disc, bronze.

11. Globe Valves, NPS 2-1/2 and Larger: Class 125; cast iron.

E. Steam Piping, 126 – 250 psig Operating Pressure:

1. Angle Valves, NPS 2 and Smaller: Class 300; with stainless-steel disc, bronze.

2. Angle Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

3. Ball Valves, NPS 2 and Smaller: Class 250, Two -piece, full port, stainless-steel trim, bronze.

4. Ball Valves, NPS 2-1/2 and Larger: Class 300, full -port, ferrous alloy.

5. High-Pressure Butterfly Valves, NPS 3 and Larger: Single-flange 720 psig CWP rating.

6. Swing Check Valves, NPS 2 and Smaller: Class 300, bronze with bronze disc.

7. Swing Check Valves, NPS 2-1/2 and Larger: Class 250, cast-iron, standard.

8. Gate Valves, NPS 2 and Smaller: Class 300, bronze.

9. Gate Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

10. Globe Valves, NPS 2 and Smaller: Class 300, stainless-steel disc, bronze.

11. Globe Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

F. Steam Condensate Piping:

1. Angle Valves, NPS 2 and Smaller: Class 150, TFE disc, bronze.

2. Angle Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

3. Ball Valves, NPS 2 and Smaller: Class 250, Two -piece, full port, stainless-steel trim, copper alloy.

4. Ball Valves, NPS 2-1/2 and Larger: Class 300, full -port, ferrous alloy.

5. High-Pressure Butterfly Valves, NPS 2-1/2 and Larger: Single-flange, 720 psig CWP rating.

6. Swing Check Valves, NPS 2 and Smaller: Class 300, bronze with bronze disc.

7. Swing Check Valves, NPS 2-1/2 and Larger: Class 250, gray iron, standard.

8. Gate Valves, NPS 2 and Smaller: Class 300, bronze.

9. Gate Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

10. Globe Valves, NPS 2 and Smaller: Class 300, stainless-steel disc, bronze.

11. Globe Valves, NPS 2-1/2 and Larger: Class 250, cast iron.

G. Select valves, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, for chilled or condenser water piping systems only.

2. For Copper Tubing, NPS 2-1/2 and Larger: Flanged ends.

3. For Steel Piping, NPS 2 and Smaller: Threaded ends.

4. For Steel Piping, NPS 2-1/2 and Larger: Flanged ends.

5. For Grooved-End, Copper Tubing and Steel Piping: Valve ends may be grooved. Do not use for steam or steam condensate piping.

## 3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. For shut-off service of hydronic systems, use

1. Up to NPS 2: Ball type.

2. NPS 2-1/2 and greater: Butterfly type.

D. For shut-off service of steam systems, use

1. Up to NPS 2: all bronze body ball valves.

2. NPS 2-1/2 and greater: iron body, bronze mounted gate valves.

E. Steam bypass valves, use

1. Up to NPS 2: all bronze globe-type valves

2. NPS 2-1/2 and greater: iron body, bronze mounted globe valves

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

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

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

I. Provide clamp lock lever handle for all valves, other than plug type, NPS 6 or smaller.

J. Provide hand wheel and closed housing worm gear for all valves, other than plug type, NPS 8 or greater.

K. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Lift Check Valves: With stem upright and plumb.

L. Install service shutoff valves for supply and return at

1. Each piece of mechanical equipment.

2. The base of vertical risers.

3. Each major section of piping, such as branches to a floor, major wings.

3.4 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping joint construction.

B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 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.

**END OF SECTION**

# SECTION 23 05 29

# HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
5. Division 23 Sections "Metal Ducts" and "Nonmetal Ducts" for duct hangers and supports.
6. Division 23 Section "HVAC Insulation" for pipe saddles at pipe hangers.

1.2 DEFINITIONS

A. MFMA: Metal Framing Manufacturers Association.

B. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

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

1.3 PERFORMANCE REQUIREMENTS

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

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

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.

2. Fiberglass pipe hangers.

3. Thermal-hanger shield inserts.

4. Powder-actuated fastener systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.

2. Metal framing systems. Include Product Data for components.

3. Fiberglass strut systems. Include Product Data for components.

4. Pipe stands. Include Product Data for components.

5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.

2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."

2. AWS D1.2, "Structural Welding Code--Aluminum."

3. AWS D1.3, "Structural Welding Code--Sheet Steel."

4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."

5. ASME Boiler and Pressure Vessel Code: Section IX.

C. Pipe hangers and supports shall conform to the recommendations of ASHRAE, ASPE, ANSI, and MSS, unless otherwise indicated.

D. Ensure anchors are acceptable per ICC for use in cracked concrete.

E. Furnish and install hangers and supports that conform to the requirements of the following codes and standards:

1. Metal Framing Manufacturers Association

a. MFMA-4, Metal Framing Standards Publication.

b. MFMA-103, Guidelines for the Use of Metal Framing.

## PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND SUPPORTS

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

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.

2. Anvil.

3. Bergen-Power Pipe Supports.

4. B-Line Systems, Inc.; a division of Cooper Industries.

5. Carpenter & Paterson, Inc.

6. Empire Industries, Inc.

7. ERICO/Michigan Hanger Co.

8. Globe Pipe Hanger Products, Inc.

9. Grinnell Corp.

10. GS Metals Corp.

11. National Pipe Hanger Corporation.

12. PHD Manufacturing, Inc.

13. PHS Industries, Inc.

14. Piping Technology & Products, Inc.

15. Tolco Inc.

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

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

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

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

B. Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.

3. GS Metals Corp.

4. Power-Strut Div.; Tyco International, Ltd.

5. Thomas & Betts Corporation.

6. Tolco Inc.

7. Unistrut Corp.; Tyco International, Ltd.

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

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

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type or threaded-anchor-type zinc-coated or stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.

b. Empire Industries, Inc.

c. Hilti, Inc.

d. ITW Ramset/Red Head.

e. MKT Fastening, LLC.

f. Powers Fasteners.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.

6. Hanger Rods: Solid, threaded steel.

2.5 PIPE STAND FABRICATION

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

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:

    a. ERICO/Michigan Hanger Co.

    b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:

    a. MIRO Industries.

    b. Portable Pipe Hangers.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:

    a. ERICO/Michigan Hanger Co.

    b. MIRO Industries.

    c. Portable Pipe Hangers.

2. Base: Plastic or stainless steel.

3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.

4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:

    a. Portable Pipe Hangers.

2. Bases: One or more plastic.

3. Vertical Members: Two or more protective-coated-steel channels.

4. Horizontal Member: Protective-coated-steel channel.

5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

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

1. Available Manufacturers:

a. Curb Technologies.

b. Pate.

c. Thy Curb.

1) Models:

a) TC-1 for insulated roof decks.

b) TC-2 for un-insulated and existing roof decks.

c) TC-3 for Bulb-T roof decks.

d. United Air

2. Pipe curbs and rails with covers shall be all welded 18 gauge galvanized steel shell and baseplate, wood nailer, and TP-1 Duro EPDM cover or TP-2 pipe cover, as detailed on the drawings, for pipe penetration(s).

2.6 EQUIPMENT SUPPORTS

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

1. Available Manufacturers:

a. Curb Technologies.

b. Pate.

c. Thy Curb.

1) Models:

a) TEMS-1 for insulated roof decks.

b) TEMS-2 for un-insulated and existing roof decks.

c) TEMS-3 for single-ply roof systems.

d. United Air

2. Equipment supports shall be all welded 18 gauge galvanized steel shell, baseplate and counterflashing with internal bulkhead re-enforcement and wood nailer.

2.7 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.

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

## PART 3 - EXECUTION

3.1 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to proper placement of inserts, anchors and other building structural attachments.

3.2 HANGER AND SUPPORT APPLICATIONS

A. Use only one type hangers and supports, by one manufacturer, for each piping service.

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

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

D. Use galvanized steel, painted, or cadmium plated components in hangers and supports unless otherwise indicated.

E. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing or provide copper-plated hangers and supports for copper piping systems where hangers are in contact with bare pipe.

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

G. Horizontal-Piping Hangers and Supports: Select size of hangers and supports to exactly fit pipe size for bare piping, and around piping insulation with saddle or shield for insulated piping. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.

8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.

9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.

10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8.

11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3.

12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Slide and Slide Plate (MSS Type 35): For support of piping where horizontal movement due to expansion and contraction may occur, and where a low coefficient of friction is desired. Support system shall include guided plate mounted on a concrete pedestal or structural steel support.

15. 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.

16. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

17. 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.

18. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.

19. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

20. 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.

21. 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.

22. 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.

H. Vertical-Piping Clamps: Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

I. Hanger-Rod Attachments: Select size of hanger rod attachments to suit hanger rods. 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.

J. Building Attachments: Select size of building attachments to suit hanger rods. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

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

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.

    b. Medium (MSS Type 32): 1500 lb.

    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

K. 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.

L. Spring Hangers and Supports: Select spring hangers and supports to suit pipe size and loading. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.

b. Vertical (MSS Type 55): Mounted vertically.

c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.3 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-69 for construction standards and applications. Install hangers, supports, clamps, and attachments as required by the following table to properly support piping from building structure.

| Pipe Size (in) | Max. Hanger Spacing (ft) | Min. Rod Size (in) | Max. Alternate Hanger Spacing (ft) | Min. Alternate Rod Size (in) |
|---|---|---|---|---|
| 1/2 | 6 | 3/8 | -- | -- |
| 3/4 | 6 | 3/8 | -- | -- |
| 1 | 7 | 3/8 | -- | -- |
| 1-1/4 | 8 | 3/8 | -- | -- |
| 1-1/2 | 9 | 3/8 | -- | -- |
| 2 | 10 | 3/8 | -- | -- |
| 2-1/2 | 11 | 1/2 | -- | -- |
| 3 | 12 | 1/2 | 8 | 3/8 |
| 3-1/2 | 13 | 5/8 | 8 | 3/8 |
| 4 | 14 | 5/8 | 8 | 3/8 |
| 5 | 16 | 5/8 | 10 | 1/2 |
| 6 | 17 | 3/4 | 10 | 1/2 |
| 8 | 19 | 7/8 | 10 | 1/2 |
| 10 | 20 | 7/8 | 10 | 1/2 |
| 12 | 20 | 7/8 | 10 | 1/2 |
| 14 | 20 | 1 | 16 | 7/8 |
| 16 | 20 | 1-1/8 | 14 | 7/8 |
| 18 | 20 | 1-1/4 | 10 | 7/8 |
| 20 | 20 | 1-1/4 | 10 | 7/8 |
| 24 | 20 | 1-1/4 | 8 | 7/8 |

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricated from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

3. Neither wire nor perforated metal shall be used to support piping, unless otherwise indicated or approved.

4. Do not support piping from other piping, unless otherwise indicated.

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 mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

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

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

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

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

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

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with Division 23 Section "HVAC Insulation" and the following:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

   c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier.

   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.

   b. Shield Dimensions for Pipe: Not less than the following:

      1) Pipes NPS 8 and Larger: Include wood inserts.

      2) Insert Material: Length at least as long as protective shield.

   c. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.4 EQUIPMENT SUPPORTS

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

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

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

3.5 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports, as required, unless otherwise indicated.

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

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

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 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 inch.

**END OF SECTION**

# SECTION 23 05 48

# VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Delegated Design requirements for system design.
2. Requirements for Manufacturer Seismic Certification.
3. Isolation pads.
4. Freestanding and restrained spring isolators.
5. Elastomeric hangers.
6. Spring hangers.
7. Spring hangers with vertical-limit stops.
8. Pipe riser resilient supports.
9. Resilient pipe guides.
10. Seismic snubbers.
11. Restraining braces and cables.
12. Steel and inertia, vibration isolation equipment bases.

B. Related Sections:

1. Division 23 Section "Common Work Results for HVAC" for description of concrete bases used as vibration isolation.
2. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for installation locations of pipe saddles at pipe hangers.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. Seismic Certification: Seismic certification refers to a manufacturer's certification for architectural, mechanical, and electrical components, supports, and attachments pursuant to ASCE/SEI 7-10 Section 13 .2 .1.2.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for vibration and seismic controls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Do not use more than one pre-approved seismic-force resistance system on any single run of pipe, duct or conduit. Mixing of multiple pre-approved systems is not acceptable.

B. Seismic-Restraint Loading: In preparation of Delegated Design, utilize seismic forces as described in ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures" as published by the American Society of Civil Engineers, unless requirements in this Section are more stringent.

1. Site Class as Defined in the IBC: C.

2. Assigned Seismic Use Group or Building Category as Defined in the IBC: IV.

a. Component Importance Factor: 1.5.

b. Assign component factors based on ASCE 7-10 Table 13.6-1 for the following:

1) Component Response Modification Factor.

2) Component Amplification Factor.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.103 g.

4. Design Spectral Response Acceleration at 1-Second Period: 0.122 g.

C. Wind-Restraint Loading:

1. Basic Wind Speed: 122 MPH.

2. Building Classification Category: IV.

3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

D. Submittal Review Conference: At time of Delegated Design Shop Drawing submission, schedule a submittal review conference with the Architect and Structural Engineer-of-Record for the project. The purpose of this conference is to review attachment locations and insure supplementary framing that is needed to

resist the loads, maintain stability or to meet other installation requirements of a pre-approved system have been accounted for in the Structural Engineer-of-Record's design.

1.4 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 23 Section "Common Work Results for HVAC" for products specified under PART 2 – PRODUCTS.

B. General Submittal Requirements:

1. Submittals shall be reviewed by Architect and the Structural Engineer-of-Record prior to submitting them to authorities having jurisdiction.

C. Contractor Statement of Responsibility:

1. Submit a written statement in accordance with IBC Chapter 17.

2. Statement shall be submitted on company letterhead.

3. In instances where trade sub-contractors are responsible for construction and implementation of seismic-force resisting systems, the representatives of these various trade sub-contractors shall sign the Contractor Statement of Responsibility.

D. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

4. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

E. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

5. Field-fabricated supports.

6. Seismic- and Wind-Restraint Details:

   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.

   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.

   d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

## 1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

2. Submit approval from Structural Engineer where supports are directly connected to structure.

B. Welding certificates.

C. Common Requirements For Qualification Data:

1. Manufacturer Seismic Qualification Certification: Where this Section and other Sections of this Division require products to meet seismic requirements; Submit certification that equipment, devices, accessories, and components will withstand seismic forces defined in this Section. Include the following:

a. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2. Manufacturer Special Seismic Certification: Where this Section and other Sections of this Division require products to meet seismic requirements; Submit certification that equipment, devices, accessories, and components will withstand seismic forces defined in this Section. Include the following:

a. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For professional engineer and testing agency.

E. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

F. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For seismic-force restraint systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Copy of the Delegated Design Shop Drawings, including AHJ approval stamp.

2. Copy of the Delegated Design Submittal, including AHJ approval stamp.

3. Copy of the Certified Seismic Inspection Report.

B. For air-mounting systems to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

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

B. Comply with seismic-restraint requirements in the IBC, unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPM number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Special Seismic Certification: Unless otherwise allowed by OSHPD, mechanical components, supports, and attachments shall be certified pursuant to ASCE/SEI 7-10 Section 13 .2 .2. Items requiring certification are as follows, but not limited to:

1. Components with hazardous contents, excluding pipes and ducts.

2. Smoke control fans.

3. Built-up or field assembled equipment.

4. Air handling and air conditioning units.

5. HVAC chillers.

6. Cooling Towers.

7. Control panels.

F. Rugged Equipment: Factory assembled, discrete components are considered rugged and deemed to comply with ASCE/SEI 7-10 Section 13 .2 .6, and do not require Special Seismic Certification, unless otherwise indicated by OSHPD. Items considered exempt are as follows:

1. Equipment and components weighing not more than 20 lbs. supported directly on structures (and not mounted on other equipment or components) with supports and attachments in accordance with Chapter 13, ASCE/SEI 7-10, as modified by Section 1616A, 2016 CBC.

G. Comply with NFPA 70.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Vibration Isolation and Control

California Dynamics Corporation, ISAT, and Korfund were removed for HCA projects.

1. Amber/Booth Company, Inc.

2. Hyspan

3. Kinetics Noise Control.

4. Mason Industries.

5. Vibro-Acoustics

B. Seismic Restraint

California Dynamics, Cooper B-Line, ISAT, Korfund, TOLCO, and Unistrut were removed for HCA projects.

1. Amber/Booth Company, Inc.

2. Hyspan.

3. Kinetics Noise Control.

4. Mason Industries.

5. Vibro-Acoustics

2.2 VIBRATION ISOLATORS

A. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a non-slip pattern and galvanized-steel base plates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

B. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Minimum Lateral Stiffness: Kx/Ky = 1.0.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Base plates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to base plate underside. Base plates shall limit floor load to 100 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled base plate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to base plate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.

3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Minimum Lateral Stiffness: Kx/Ky = 1.0.

6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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

E. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Minimum Lateral Stiffness: Kx/Ky = 1.0.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

F. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Minimum Lateral Stiffness: Kx/Ky = 1.0.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

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

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

2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

A. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

B. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

C. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch-thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.

a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.

b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

c. Minimum Additional Travel: 50 percent of the required deflection at rated load.

d. Minimum Lateral Stiffness: Kx/Ky = 1.0.

e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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

D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Housekeeping Pads: Reinforced concrete 4" or 6" tall with 1" chamfer on all top edges.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

b. The weight of each inertial block shall not be less than 150% of supported equipment.

c. Extend block minimum 4" beyond equipment base.

d. Chamfer edges minimum 1".

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Channels shall be minimum 6" deep. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

## 2.5 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.

2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.

3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener:

1. Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

2. Reinforcing steel angle clamped to hanger rod.

F. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

## PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

3.2 APPLICATIONS

A. Base: None.

1. Suspended Equipment:
    a. Fan Systems:
        1) Fan Coil Units, up to 500 CFM or 200 pounds operational weight.
        2) Fan Powered Terminal Boxes.
    b. Piping in Mechanical Rooms, up to 3" NPS.
2. Isolator: Spring hanger with 1" deflection.

B. Base: None.
1. Suspended Equipment:
    a. Fan Systems:
        1) Axial Fans.
        2) Centrifugal, in-line Fans.
        3) Factory Fabricated AHUs.
            a) Provide structural steel channel to support unit and suspend frame from structure.
        4) Fan Coil Units, larger than 500 CFM or 200 pounds operational weight.
    b. Suspended Heat Exchangers.
    c. Suspended Expansion Tanks.
    d. Piping in Mechanical Rooms, greater than 3" NPS.
2. Isolator: Spring hanger with 2" deflection.

C. Base: Roof Curbs or Rails.
1. Equipment:
    a. Roof Exhaust Fans.
    b. Air Cooled Condensing Units.
    c. Factory Fabricated AHUs without internal isolation.
2. Isolator:
    a. Pad integral with curb.

b. Restrained, open spring type with 1" deflection.

D. Base: Reinforced Concrete Inertia Block

1. Equipment: Pumping Systems

a. Fire.

b. Chilled water.

c. Condenser water.

d. Heating water.

e. Grit separator.

2. Isolator: Freestanding, open spring type with 1.5" deflection.

E. Base: 4" Housekeeping Pad

1. Equipment:

a. Floor mounted Fan Systems.

1) Cabinet fans.

2) Centrifugal fans:

a) DWDI.

b) In-line.

c) Utility vent sets.

3) Factory Fabricated AHUs.

b. Floor mounted Reciprocating Air Compressors.

2. Isolator: Restrained, open spring type with 2" deflection.

F. Miscellaneous Systems

1. Chillers

a. Base: 6" Housekeeping pad.

b. Isolator: Restrained, open spring type with 1" deflection.

2. Cooling Towers

a. Base: As designed by Structural Engineer.

b. Isolator: Restrained, open spring type with 1" deflection.

3. Factory Fabricated, Internally Isolated, AHUs.

a. Base:

1) 6" Housekeeping pad.

2) Factory fabricated, sound attenuating curb.

b. Isolator: Pad.

4. Jockey Pump

a. Base: 6" housekeeping pad.

b. Isolator: None.

5. Rotary, Centrifugal, and Screw Air Compressors

a. Base: 4" Housekeeping pad.

b. Isolator: Restrained, open spring type with 1" deflection.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

C. Install seismic isolators and restraints as required by delegate design calculations.

D. Install hanger rod stiffeners to prevent buckling of hanger rods due to seismic forces.

E. Install spring isolators for the closest three hangers for all piping attached to rotating equipment.

F. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

G. Piping Restraints:

1. Comply with requirements in MSS SP-127.

2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

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

I. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

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

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

L. Strength of Support and Seismic-Restraint Assemblies: Select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

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

N. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

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

## 3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.

## 3.5 IDENTIFICATION

A. Install brass identification tags at all seismic brace locations. Tags to include the following information:

1. Unique keyed identification number that corresponds to nomenclature used to mark location on shop drawings and calculations.

2. Specific G-force the system at that location is designed to resist.

3. Maximum brace reaction to the structure.

4. For Individually suspended items: Maximum conduit size.

5. For Trapeze or Multiple pipe hangers: Maximum pounds-per-lineal-foot.

6. For Suspended Equipment: Maximum weight of equipment.

## 3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

6. Measure isolator restraint clearance.

7. Measure isolator deflection.

8. Verify snubber minimum clearances.

9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

E. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

F. Prepare a report that identifies unit components and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

3.7 ADJUSTING

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

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

C. Adjust active height of spring isolators.

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

**END OF SECTION**

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# SECTION 23 05 53

# IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.

1.2 RELATED SECTIONS

A. Division 09, Section "High-Performance Coatings" for painting of systems.

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. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, laminated phenolic with a black surface and white substrate for mechanical engraving, 1/16 inch minimum thickness, beveled edges, and having predrilled holes for attachment hardware.

2. Letter Color: White.

3. Background Color: Black.

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

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

6. Minimum Letter Size: 1/2 inch. 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.

B. Label Content: Include equipment's Drawing designation or unique equipment number as directed by owner. Secondary lettering shall indicate date of installation.

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

D. Punched plastic tape for labels is not acceptable.

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: White.

C. Background Color: Red.

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

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

F. Minimum Letter Size: 1 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Labels shall conform to ANSI A13.1 and the following table:

| Outside Diameter of Pipe or of Covering | Height of Letters |
|---|---|
| ¾" to 1-1/4" | ½" |
| 1-1/2" to 2" | ¾" |
| 2-1/2" to 6" | 1-1/4" |
| 8" to 10" | 2-1/2" |
| Over 10" | 3-1/2" |

B. Available Manufacturers: Seton, Brady, or Westline.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction. For steam systems, also include line pressure on label.

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.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with minimum 1-inch letters.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link chain and S-hook or beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

## 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 using fasteners or adhesives.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding:

1. Painting of piping is specified in Division 09 Section "High-Performance Coatings."

2. Provide color coding of all pipe services, either paint or PVC wrap, in the following:

a. Boiler Rooms

b. Central Plants / Power Houses

c. Mechanical Rooms

d. Where uninsulated and routed exterior to the building

3. All piping, shall be painted in exposed areas and in unconditioned areas such as loading docks, parking garages, canopies, and exterior soffits.

4. Use paint with stencils to neatly identify piping and flow direction. Piping shall be stenciled or labeled at 20-foot intervals and at least once in each separate space through which the pipe passes.

5. Color-coded plastic wrap-around labels are an acceptable alternative to painting on insulated pipe. Plastic labels shall only be applied in accordance with code-limitations for smoke developed and flame spread ratings. PVC labels shall only be applied by permission of AHJ.

6. Color code piping in accordance with current facility standard. Where no standard exists for color-coding, provide in accordance with Piping Color Table below:

| HCA Piping Color Table | |
|---|---|
| **Piping** | **Color Description** |
| Low Temp Supply | Dark Purple |
| Low Temp Return | Light Purple |
| Chilled Water Supply | Dark Blue |
| Chilled Water Return | Light Blue |
| Condenser Water Supply | Bright Green |
| Condenser Water Return | Dark Green |
| Hot Water Supply | Bright Red |
| Hot Water Return | Dark Red |
| Condensate | Dark Orange |
| Steam | Bright Orange |
| Natural Gas | Bright Yellow |
| Fuel Oil | Brown |

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 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.

7. In no case shall a line enter or leave a room without being identified.

8. Secure identification markers to piping by firmly pressing markers in place, following removal of protective covering. Additionally secure by banding ends

of markers in place using 1/2 inch wide aluminum bands of the type normally used to secure insulation in place.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems except:

1. Check valves.

2. Valves within factory-fabricated equipment.

3. Shutoff valves directly adjacent to equipment.

4. Faucets.

5. Convenience and lawn-watering hose connections.

6. HVAC terminal devices.

B. Emergency shut-off valves: Provide permanent equipment label with minimum 1" high lettering. These valves include valves 2" and larger for the following services:

1. Chilled water.

2. Heating water.

3. Steam.

4. Steam condensate.

5. Natural gas.

C. List tagged valves in a valve schedule and provide to Owner with floor plans indicating location.

3.5 CEILING MARKERS

A. Install labels affixed to the ceiling grid closest to the device to aid in locating components above ceilings.

B. Use color scheme, label style, label material, and lettering as required by Owner's campus standard.

C. Components to be marked:

1. Emergency valves.

2. Fire dampers.

3. Fire-smoke dampers.

4. Manual balance dampers

5. Smoke dampers.

6. Terminal boxes.

7. Valves.

**END OF SECTION**

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# 4SECTION 23 05 93

# TESTING, ADJUSTING, AND BALANCING FOR HVAC

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

a. Constant-volume air systems.

2. HVAC equipment quantitative-performance settings.

3. Verifying that automatic control devices are functioning properly.

4. Reporting results of activities and procedures specified in this Section.

1.2 RELATED SECTIONS

A. Division 01, General Commissioning Requirements contains testing forms for pre-testing and functional testing.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of systems or equipment.

S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 6 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review based on system readiness reports and pre-functional check lists.

F. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

G. Sample Report Forms: Submit two sets of sample TAB report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.

2. Serial number.

3. Application.

4. Dates of use.

5. Dates of calibration.

I. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. The TAB firm shall be organized to provide independent professional testing and balancing services. The firm shall have a minimum of one (1) Professional Engineer licensed in the project's state, in good standing with the board and have a current registration.

B. The TAB firm shall be financially independent from all other entities associated with the project and be an active participant in commissioning activities as described in Section 01 91 13, General Commissioning Requirements.

C. The TAB firm will be directly contracted with the General Contractor.

D. All personnel used on the job site shall be either TAB engineers or TAB technicians, who shall have been permanent, full-time employees of the Tab firm for a minimum of six (6) months prior to working on the project.

E. Upon request, the TAB Firm shall submit the following to the Architect/Engineer and/or Owner for approval prior to commencing services:

1. Name and biographical data of the Professional Engineer and all personnel to be assigned to this project.

2. Proof of company operation for minimum of five (5) years.

F. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

G. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the

details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: As a minimum, include the following:

   a. Submittal distribution requirements.

   b. The Contract Documents examination report.

   c. TAB plan.

   d. Work schedule and Project-site access requirements.

   e. Coordination and cooperation of trades and subcontractors.

   f. Coordination of documentation and communication flow.

   g. Coordinate submission of FMS sequence and schematics for review by TAB firm.

H. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

I. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

J. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

K. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

L. Sound values for all spaces shall meet or exceed FGI requirements.

1.6 PROJECT CONDITIONS

A. Owner Occupancy: Owner may occupy the completed areas of the site and existing building prior to substantial completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide minimum seven days' advance notice for each test. Include scheduled test dates and times.

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

C. The Contractor shall start up and test all materials and equipment which normally require testing. All piping, etc., shall be tested to meet code requirements or the specification requirements, whichever is the more stringent. All equipment shall operate a sufficient length of time at the Contractor's expense to prove to the Architect/Engineer and/or Owner that the equipment is free from mechanical defects, runs smoothly and quietly and performs satisfactorily to meet the requirements set forth in the mechanical plans and specifications.

D. In order that all HVAC systems can be properly tested, adjusted and balanced, the Contractor shall operate the HVAC systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB, and shall further operate and pay all costs of operation during the TAB period. Operating expenses to be paid for by the Contractor will include, but not necessarily be limited to, the following:

1. Utility costs; electrical, water, gas, etc.

2. Personnel costs to start, operate and stop all HVAC equipment.

3. All start-up labor and material costs.

4. All maintenance costs.

5. Water treatment.

E. The plans and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of testing and balancing the HVAC systems to obtain optimum operating conditions. The Contractor shall install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as required.

F. The Contractor shall provide and coordinate services to repair or replace any and all deficient items or conditions found before and during the TAB period.

G. As a part of this Project Contract, the Contractor shall make any changes in the sheaves, belts, motors, dampers and valves or the addition of dampers and/or valves as required to correctly balance the HVAC systems as required at no additional cost.

H. Provide sufficient time in Project Contract completion schedule to permit the completion of TAB services prior to Owner occupancy of the Project.

I. The Contractor shall furnish without charge to the TAB Firm:

1. One set of mechanical specifications and all addenda.

2. All pertinent change orders.

3. Complete set of mechanical plans with latest revisions.

4. "As-installed" drawings.

5. Approved control diagrams and submittals.

6. Approved manufacturer's submittals for all HVAC equipment.

1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

## PART 2 - PRODUCTS (Not Applicable)

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

3. Based on examination of the Contract Documents, to recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Examine approved submittal data of HVAC and plumbing systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

D. Examine design data, including HVAC and plumbing system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC and plumbing system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC and plumbing system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

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

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine control system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at indicated values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to indicated values.

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

3.2 PREPARATION

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

B. Prepare a TAB plan that includes strategies and step-by-step procedures.

C. The Contractor shall complete system readiness checks, prepare system readiness reports, and prefunctional tests including the following:

1. Permanent electrical power wiring is complete.

2. Hydronic systems are filled, clean, and free of air.

3. Control systems are operational.

4. Equipment and duct access doors are securely closed.

5. Balance, smoke, and fire dampers are open.

6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. TAB firm shall coordinate with Contractor to gather all required system points and data without voiding manufacturers' warranties. Facility personnel and factory-authorized service representatives may also be required.

B. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" and this Section.

C. Cut insulation, penetrate pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

D. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

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

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Provide a marked-up set of mechanical plans or "as-built" duct layouts of systems that includes numbering of each HVAC device that corresponds to the respective item in the TAB report.

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. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

K. Check for proper sealing of air duct system.

L. When air systems are tied to a common plenum, duct, or louver, test the connected equipment at full design CFM simultaneously, unless otherwise indicated.

M. Verify building and space pressure relationships in all modes of operation.

N. Measure system performance with the pressure drop across filters at the value specified for dirty filters.

3.5 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.

3.6 GENERAL PROCEDURES FOR DOMESTIC HOT WATER SYSTEMS

A. Balance domestic hot water recirculation, to ensure proper flow through all mains and branches. Tune system until hot water is delivered to the most remote fixture within the allowable time as required by the AHJ.

3.7 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.

2. Measure motor voltage and amperage. Compare the values to motor nameplate information.

3. Check the refrigerant charge.

4. Check the condition of filters.

5. Check the condition of coils.

6. Check the operation of the drain pan and condensate drain trap.

7. Check bearings and other lubricated parts for proper lubrication.

8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.

1. New filters are installed.

2. Coils are clean and fins combed.

3. Drain pans are clean.

4. Fans are clean.

5. Bearings and other parts are properly lubricated. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.

2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.

3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.

4. Air balance each air outlet.

3.8 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures for systems with pneumatic components and device positions and correlate with airflow and water flow measurements.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. For pneumatic systems, check main control supply-air pressure and observe compressor and dryer operations.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.9 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans:

a. Up to 5000 cfm: 0 to plus 10 percent.

b. Larger than 5000 cfm: 0 to plus 5 percent.

2. Air Devices

a. Exhaust: 0 to -10 percent.

b. Return: +/-5 percent.

c. Supply: 0 to +10 percent.

3. Hydronic Flow Rates

a. Pumps: 0 to +10 percent.

b. Equipment: 0 to +5 percent.

3.10 REPORTING

A. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.11 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Pump curves.

2. Fan curves.

3. Manufacturers' test data.

4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB firm who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.

    b. Notable characteristics of systems.

    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer, type size, and fittings.

14. Notes to explain why certain final data in the body of reports varies from indicated values.

E. Provide a marked-up set of mechanical plans or "as-built" layouts of systems that include numbering of each HVAC device that corresponds to the respective item in the TAB report.

1. Quantities of outside, 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.

F. Supplemental documentation: In coordination with the test reports below, provide the following:

1. Measure and include in the report the AHU supply and return fans' flow, rpm, hp, and sensed duct static pressure at the dirty differential pressure drop across both the pre-filter and final filter.

2. Report all the individual velocity measurements from duct or AHU traverses in grid format.

3. Include a static profile of each AHU with the supply fan controlling to the minimum sensed duct static pressure necessary for the system terminal units to achieve maximum cooling design flow simultaneously. This static pressure shall be documented in the report and shall become the duct static pressure set point.

4. Record the VFD speed for all supply and return fan measurements included in the report.

5. Where AHUs share a common outside air duct, relief duct, or louver, test those AHUs simultaneously in the 100% economizer mode with all boxes at 100% cooling to verify the supply duct static set point and the design supply/return air volume differential are maintained.

G. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.

b. Location.

c. Coil type.

d. Number of rows.

e. Fin spacing in fins per inch o.c.

f. Make and model number.

g. Face area in sq. ft..

h. Tube size in NPS.

i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Average face velocity in fpm.

c. Air pressure drop in inches wg.

d. Outside-air, wet- and dry-bulb temperatures in deg F.

e. Return-air, wet- and dry-bulb temperatures in deg F.

f. Entering-air, wet- and dry-bulb temperatures in deg F.

g. Leaving-air, wet- and dry-bulb temperatures in deg F.

h. Water flow rate in gpm.

i. Water pressure differential in feet of head or psig.

j. Entering-water temperature in deg F.

k. Leaving-water temperature in deg F.

l. Refrigerant expansion valve and refrigerant types.

m. Refrigerant suction pressure in psig.

n. Refrigerant suction temperature in deg F.

o. Inlet steam pressure in psig.

H. 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 Btuh.

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. Sheave dimensions, center-to-center, 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 Btuh.

i. High-fire fuel input in Btuh.

j. Manifold pressure in psig.

k. High-temperature-limit setting in deg F.

l. Operating set point in Btuh.

m. Motor voltage at each connection.

n. Motor amperage for each phase.

o. Heating value of fuel in Btuh.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.

b. Location.

c. Make and type.

d. Model number and size.

e. Manufacturer's serial number.

f. Arrangement and class.

g. Sheave make, size in inches, and bore.

h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Motor Data:

a. Make and frame type and size.

b. Horsepower and rpm.

c. Volts, phase, and hertz.

d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

g. Number of belts, make, and size.

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.

J. 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.

K. 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.

L. Pump Test Reports:

1. Unit Data:

a. Unit identification.

b. Location.

c. Service.

d. Make and size.

e. Model and serial numbers.

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. Impeller size.

M. Boiler Test Reports:

1. Unit Data:

   a. Unit identification.

   b. Location.

   c. Service.

   d. Make and type.

   e. Model and serial numbers.

   f. Fuel type and input in Btuh.

   g. Number of passes.

   h. Ignition type.

   i. Burner-control types.

   j. Voltage at each connection.

   k. Amperage for each phase.

2. Test Data (Indicated and Actual Values):

   a. Operating pressure in psig.

   b. Operating temperature in deg F.

   c. Entering-water temperature in deg F.

   d. Leaving-water temperature in deg F.

   e. Number of safety valves and sizes in NPS.

   f. Safety valve settings in psig.

   g. High-limit setting in psig.

   h. Operating-control setting.

   i. High-fire set point.

   j. Low-fire set point.

   k. Voltage at each connection.

   l. Amperage for each phase.

m. Draft fan voltage at each connection.

n. Draft fan amperage for each phase.

o. Manifold pressure in psig.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.12 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.

b. Measure water flow of at least 5 percent of terminals.

c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.

d. Measure sound levels at two locations.

e. Measure space pressure of at least 10 percent of locations.

f. Verify that balancing devices are marked with final balance position.

g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.

3. Owner shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

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

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

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

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# SECTION 23 07 00

# HVAC INSULATION – DUCT, EQUIPMENT, AND PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:

a. Calcium silicate.

b. Cellular glass.

c. Fiberglass.

d. Flexible elastomeric.

e. Mineral or glass fiber.

f. Phenolic.

g. Polyolefin.

2. Fire-rated insulation systems.

3. Factory-applied jackets.

4. Field-applied cloths.

5. Field-applied jackets.

6. Adhesives.

7. Mastics.

8. Lagging adhesives.

9. Sealants.

10. Tapes.

11. Securements.

B. Related Sections:

1. Division 22 Section "Plumbing Insulation."

2. Division 23 Section "Metal Ducts" for duct liners.

3. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for installation locations of pipe saddles at pipe hangers.

1.2 ACTION SUBMITTALS

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

B. Calculations: For insulation submitted outside of the conductivity range per the "Minimum Pipe Insulation Thickness" Table for the application listed, submit thickness calculations.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail insulation application at pipe expansion joints for each type of insulation.

4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

5. Detail removable insulation at piping specialties, equipment connections, and access panels.

6. Detail application of field-applied jackets.

7. Detail application at linkages of control devices.

8. Detail field application for each equipment type.

1.3 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.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the United

States Department of Labor, Employment and Training Registered Apprenticeship Program.

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

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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 size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork 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.

1.7 SCHEDULING

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

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

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fiberglass

1. Johns-Manville.
2. K-Flex.
3. Knauf Fiberglass.
4. Manson (Certain Teed).
5. Owens-Corning.
6. Pittsburg-Corning.

B. Flexible Elastomeric

1. Aeroflex / Aerocel EPDM
2. Armacell / Armaflex
3. RBX Industries / Rubatex

C. Phenolic

1. Resolco / Insul-Phen

D. Polyisocyanurate

1. Dow / Trymer

E. Polyolefin

1. Nomaco/ IMCOA Imcolock

2.2 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, cellular or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.

2. Special-Shaped Insulation: ASTM C 552, Type III.

3. Board Insulation: ASTM C 552, Type IV.

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.

H. Fiberglass

1. Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

2. Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density.

I. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials with a built-in vapor barrier. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

J. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Mineral Wool: ASTM C 547; preformed, high temperature insulation; 'k' value of 0.35 at 300 degrees F.

M. Phenolic:

1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.

3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

4. Factory-Applied Jacket: FSJ for all applications unless otherwise indicated.

N. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; FlameChek.

b. Johns Manville; Firetemp Wrap.

c. 3M; Fire Barrier Wrap Products.

d. Unifrax Corporation; FyreWrap.

2.4 THERMAL-HANGER SHIELD INSERTS

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

B. Available Manufacturers:

1. Carpenter & Paterson, Inc.

2. ERICO/Michigan Hanger Co.

3. PHS Industries, Inc.

4. Pipe Shields, Inc.

5. Rilco Manufacturing Company, Inc.

6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

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

F. For Clevis or Band Hangers: Insert and shield shall cover lower 360 degrees of pipe.

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

2.5 ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide insulation adhesive and jacket manufacturer shall provide jacket adhesive.

B. 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.

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

D. Cellular-Glass and Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

F. 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.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.6 MASTICS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide mastics.

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.

2. Service Temperature Range: Minus 20 to plus 360 deg F.

3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

4. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.

2. Service Temperature Range: Minus 20 to plus 200 deg F.

3. Solids Content: 63 percent by volume and 73 percent by weight.

4. Color: White.

2.7 LAGGING ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide lagging adhesives

B. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.

2. Service Temperature Range: Minus 50 to plus 360 deg F.

3. Color: White.

2.8 SEALANTS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide sealants

B. Joint Sealants for Cellular-Glass, and Phenolic Products:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Permanently flexible, elastomeric sealant.

3. Service Temperature Range: Minus 100 to plus 300 deg F.

4. Color: White or gray.

C. 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.

D. 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.

2.9 INSULATING CEMENT

A. ASTM C 195; hydraulic setting mineral fiber thermal insulating cement with dry density of no more than 38 lb/ft3 thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.

B. Acceptable manufacturers: RAMCO or approved equal.

2.10 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.

4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

5. PVDC Jackets

   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

   b. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

   c. for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

   d. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.11 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.12 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Johns Manville; Zeston.

    b. P.I.C. Plastics, Inc.; FG Series.

    c. Proto PVC Corporation; LoSmoke.

    d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: Color-code jackets based on system. Color as selected by Architect.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.

5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Products, Division of ITW; Metal Jacketing Systems.

    b. PABCO Metals Corporation; Surefit.

    c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

    a. Factory cut and rolled to size.

    b. Finish and thickness are indicated in field-applied jacket schedules.

    c. 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.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. Factory cut and rolled to size.

b. Material, finish, and thickness are indicated in field-applied jacket schedules.

c. 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.

D. PVDC Jackets:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

2. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

3. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

4. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.13 TAPES

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Avery Dennison Corporation, Specialty Tapes Division.

2. Compac Corp.

3. Ideal Tape Co., Inc., an American Biltrite Company.

4. Venture Tape.

5. Dow Chemical Company (The).

B. 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.

C. 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.

D. 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.

E. 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.

F. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.

2. Film Thickness: 4 mils.

3. Adhesive Thickness: 1.5 mils.

4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch in width.

G. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.

2. Film Thickness: 6 mils.

3. Adhesive Thickness: 1.5 mils.

4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch in width.

2.14 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Childers Products; Bands.

b. PABCO Metals Corporation; Bands.

c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

B. Insulation Pins and Hangers:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. AGM Industries, Inc.

b. GEMCO.

c. Midwest Fasteners, Inc.

d. Nelson Stud Welding.

2. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, minimum 0.106-inch-diameter shank, length to suit depth of insulation indicated.

3. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, minimum 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

4. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

b. Spindle: Match ductwork material, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

b. Spindle: Match ductwork material, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers 0.016-inch-thick, Match pin material, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

2.15 PIPE INSULATION HANGER SHIELDS

A. Where hangers are placed outside the jackets of pipe insulation, provide shields or equivalent by Elcen Metal Products Company.

B. Insulation and shields shall consist of a 360 degree insert of high-density, 100 psi, waterproof calcium silicate, encased in a 360 degree galvanized sheet steel shield. Insert shall be same thickness as adjoining pipe insulation, and shall extend 1-inch beyond sheet metal shield in each direction. Shield lengths and minimum sheet metal gauges shall be as directed below:

| PIPE SIZE | SHIELD LENGTH | MINIMUM GAUGE |
|---|---|---|
| 1/2" to 8" | 12" | 16 |
| 10" & Larger | 22" | 16 |

C. Insulation and shields for Phenolic type insulation shall consist of a 360 degree insert of high-density (minimum 5 lbs/cu.ft.) phenolic insulation by the same manufacturer, encased in a 360 degree galvanized sheet steel shield. Insert shall be same thickness as adjoining pipe insulation, and shall extend 1-inch beyond sheet metal shield in each direction. Shield length and gauge per above table.

D. Shields shall be Model A1000 – A9000, except for pipe roller applications and where pipe hanger spacing exceeds 10 feet, then provide Model CSX-CW.

E. At the Contractor's option, shop-fabricated galvanized metal shields may be provided based on approved shop drawings. Length and gauge of sheet metal shall be as specified above.

2.16 PREMANUFACTURED COVERS

A. Preformed manufactured PVC fitting covers with rigid one piece (half-shell) preformed rigid insulation.

## PART 3 - EXECUTION

3.1 GENERAL

A. Materials shall be applied by a qualified insulation applicator/workman skilled in this trade. Insulation shall be installed in accordance with the manufacturers written instructions and in accordance with recognized industry standards. Mechanical fasteners shall be used whenever possible to assure permanent construction. Unsightly work shall be cause for rejection.

B. Prior to installation of any insulation materials to ferrous piping systems, the piping surfaces shall be thoroughly cleaned of all mill scale, grease and dirt and passed pressure testing.

C. Non-compressible insulation material shall be installed at hanger supports on cold piping to prevent damage to insulation and vapor barrier. All wet duct and pipe insulation shall be replaced.

D. Insulation of cold surfaces shall be vapor-sealed to prevent condensation.

E. Minimum thickness of insulation shall be as scheduled unless alternate thicknesses can be shown to meet energy performance and approved by the Engineer.

F. Where piping system insulation is specified, cover valves, strainers, unions, flanges, and fittings with pre-manufactured valve and fitting covers.

G. Install pipe insulation hanger shields.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, there shall be no exceptions.

I. Duct insulation shall terminate at fire/smoke damper sleeves. A separate strip of insulation shall be provided around the sleeve and sealed at the wall.

J. Miscellaneous Applications

1. Refrigerant suction lines within air cooled condensing units, heat pumps and chillers.

K. Unless indicated otherwise, insulate pipe and equipment that operates:

1. 10 degrees or lower than ambient space temperature.

2. 10 degrees of higher than ambient space temperature.

L. All steam valves and regulators at and below an elevation of 7' - 0" A.F.F. shall be insulated with removable asbestos free insulation jackets with Velcro fasteners to allow easy installation and removal.

3.2 APPLICATION TYPES

A. Equipment

1. E1: Cut insulation to fit contour of equipment, and secure by means of bands, stick-clips, weld-pins and lugs or adhesives as required for each individual piece of equipment. Provide vapor barrier and finish as required for each specific application. Provide new cold surfaces of pumps with accessible boxes that easily separate coincidental with parting line of evaporator heads and pump casings. Resulting insulation joints shall be covered with a self-sealing, vapor-barrier tape. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

B. Piping

1. P1: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Seal with double tape self-sealing adhesives.

2. P2: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

3. P3: Same as P2, except install insulation over heat trace tape. Finish with metal jacket.

C. Ductwork

1. D1: Apply fiberglass board insulation to ducts with mechanical fasteners such as stick-clips or weld-pins (with tape and mastic) spaced as required to install full pieces of board insulation. Space on 12" centers (maximum) on the bottom of each duct and plenum. Cover joints and seams in vapor barrier facings with 3" wide matching tape, or with vapor-barrier mastic reinforced with 3" glass mesh reinforcement. Provide an additional layer of insulation board where duct-standing seams exceed the insulation thickness. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

2. D2: Wrap flexible fiberglass insulation around ducts and secure. Additionally, ducts up to 36" wide shall be secured with outward clinching

staples and ductwork larger than 36 inches shall be secured with stick pins. Lap insulation a minimum of four (4) inches and seal with an approved vapor barrier mastic. Reinforce lap with a three (3) inch wide band of glass mesh reinforcement. Seal staples and pins and raw glass to duct where insulation terminates as well as penetrations in vapor barrier jacket with an approved vapor barrier mastic.

3.3 INSULATION SCHEDULE KEYS

**Insulation Types Key**

| | Type | Maximum K Factor @ 75°F | Temp. Limit °F | Density Lb. Per Cubic Foot | Federal Spec. Compliance |
|---|---|---|---|---|---|
| 1. | Calcium Silicate | 0.38 | 1200 | 14 | HH-I-523C |
| 2. | Fiberglass (Rigid) | 0.23 | 450 | 3 | ASTM C 547 Type 1 |
| 3. | Fiberglass Flexible Duct Wrap | 0.25 | 250 | 1.5 | |
| 4. | Foamed Glass (Cellular) | 0.36 | 850 | 9 | HH-I-1751/3A |
| 5. | Foamed Plastic (Flexible) | 0.25 | 220 | 5 | HH-I-573 |
| 6. | High Temperature Fiberglass | 0.23 | 850 | 3 | HH-1-558B |
| 7. | Insulating Cement | 0.7 | 1700 | | SS-C-160 |
| 8. | Phenolic | 0.13 | 250 | 2.5 | ASTM C 1126 |
| 9. | Flexible Elastomeric | 0.27 | 220 | | ASTM C 177 or C518 |
| 10. | Polyolefin | 0.25 | 200 | 2 | ASTM C 177 or C518 |

**Finishes Key**

| | |
|---|---|
| F1. | 8-ounce glass cloth |
| F2. | Insulation cement |
| F3. | 0.016 aluminum, plain, up through 12" pipe size; 0.016 aluminum, corrugated, for pipe sizes 14" and larger |
| F4. | 15-mil PVC |
| F5. | Foil/reinforced/kraft jacket (vapor barrier) |
| F6. | 1/4-inch weatherproof mastic with glass mesh reinforcement |
| F7. | 1/16" vapor barrier mastic (0.05 perm rating) with glass mesh reinforcement |
| F8. | White all-service jacket (vapor barrier) with self-sealing lap, or taped joints |
| F9. | Two coats vinyl lacquer type white paint |
| F10. | Canvas jacketing of 6 oz. Minimum, 100% cotton woven fabric with 25/50 flame/smoke rating and equal to Fattal's Thermocanvas Recovery Jacket. |

3.4 DUCT AND PLENUM INSULATION

A. Outside Air Ducts and Plenums in Concealed or Exposed Locations

1. Minimum R-value: 8.

2. Insulation Materials:

a. Rigid Fiberglass.

b. Cellular Glass

c. Phenolic

3. Application Type: D1.

4. Indoor Finish: F8.

5. Outdoor Finish: F1 and F2.

B. Supply Air Ducts and Plenums in Concealed Locations

1. Minimum R-value: 6.

2. Insulation Materials: Fiberglass Flexible Duct Wrap.

3. Application Type: D2.

4. Indoor Finish: F5.

5. Outdoor Finish: F1 and F2.

C. Supply Air Ducts and Plenums in Exposed Locations

1. Minimum R-value: 8.

2. Insulation Materials:

a. Rigid Fiberglass.

b. Cellular Glass

c. Phenolic

3. Application Type: D1.

4. Indoor Finish: F8.

5. Outdoor Finish: F1 and F2.

D. Relief, Return, Exhaust Ducts, and Plenums, and Air Devices in Concealed Locations Under an Exposed Roof.

1. Minimum R-value: 8.

2. Insulation Materials: Fiberglass Flexible Duct Wrap.

3. Application Type: D2.

4. Indoor Finish: F5.

5. Outdoor Finish: F1 and F2.

E. Relief, Return, Exhaust Ducts, and Plenums, and Air Devices in Exposed Locations Under an Exposed Roof.

1. Minimum R-value: 8.

2. Insulation Materials:

a. Rigid Fiberglass.

b. Cellular Glass

c. Phenolic

3. Application Type: D1.

4. Indoor Finish: F8.

5. Outdoor Finish: F1 and F2.

F. Additional Duct Installations

1. Items Not Insulated:

a. Fibrous-glass ducts.

b. Factory-insulated flexible ducts.

c. Factory-insulated plenums and casings.

d. Flexible connectors.

e. Vibration-control devices.

f. Factory-insulated access panels and doors.

2. Where duct is exposed outdoors, protect the ductwork with one of the following:

a. F9 with color as chosen by Architect.

b. F3 where duct is externally insulated.

3.5 EQUIPMENT INSULATION

A. Equipment above ambient temperature, excluding factory insulated assemblies.

1. Equipment includes, unless otherwise indicated:

a. Hot Water:

1) Water-to-Water Heat Exchangers.

2) Expansion tanks.

3) Air Separators.

4) Pumps.

5) Laundry Exhaust Assemblies.

6) Humidifiers.

b. Steam:

1) Blowdown Heat Recovery Unit.

2) Blowdown Separator Flash Tanks.

3) Boiler Breeching.

4) Dearator.

5) Flash Tanks.

6) Steam Condensate Pumps.

7) Steam-to-water Heat Exchanger.

8) Steam Surge Tank.

c. Exhaust services:

1) Medical gas equipment

2. Insulation Materials:

a. Laundry exhaust and humidifiers: High Temperature Fiberglass.

b. All others: Rigid Fiberglass.

3. Application Types:

a. Laundry exhaust and humidifiers: D1.

b. All others: E1.

4. Indoor Finish:

a. Laundry exhaust: F6 and F3.

b. Humidifiers: F10.

c. All others: F2 and F1.

5. Outdoor Finish:

a. Laundry exhaust: F6 and F3.

b. Humidifiers: no application.

c. All others: F8 and F3.

B. Equipment Below Ambient Temperature, excluding factory insulated assemblies.

1. Equipment includes, unless otherwise indicated:

a. Chilled and Condenser Water:

1) Water-to-Water Heat Exchangers.

2) Expansion tanks.

3) Air Separators.

4) Pumps.

5) Chillers.

2. Insulation Materials:

a. Chillers and pumps:

1) Rigid Insulation.

2) Foam Glass.

3) Foam Plastic.

b. All others: Rigid Fiberglass.

3. Application Type: E1.

4. Indoor Finish:

a. Chillers and pumps (to be used with Insulation Material above, respectively):

1) F2 and F1.

2) F2 and F3.

3) F9.

b. All others: F2 and F1.

5. Outdoor Finish:

a. Chillers and pumps (to be used with Insulation Material above, respectively):

1) F3.

b. All others: F8 and F3.

C. Equipment insulation thicknesses and performance shall be based on Minimum Pipe Insulation Thickness schedule.

D. Insulation for pump casings, suction diffusers and heat exchangers shall be removable and replaceable without damaging insulation.

3.6 PIPING INSULATION

A. Minimum insulation thicknesses are scheduled below.

B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following unless there is a potential for personnel injury.

1. Drainage piping located in crawl spaces.

2. Underground piping.

D. Fitting and Valve Covers:

1. Fitting covers shall be of preformed PVC for indoor service and metal for outdoor service.

2. Insulation material shall be rigid and of the same or greater material type and thickness, density and conductivity as the adjoining pipe. Blanket inserts will not be allowed.

3. Fittings on fiberglass pipe insulation shall be mitered insulation up to 2" diameter and molded fittings for 2½" and larger.

4. Insulation on steam control valves, pressure reducing valves, calibrated balance valves and triple duty valves shall be provided with a manufactured removable insulation cover. Insulated covers shall be heavy canvas type, filled with insulating material and leather laces or straps to secure cover around valve or fitting.

E. Chilled Water, Cooling Condensate, and Refrigerant Piping Indoors, Concealed or Exposed.

1. Insulation Materials:

a. Cellular Glass, with mitered section fittings only.

b. Phenolic.

2. Application Type: P2.

3. Finish:

a. In equipment rooms: F8.

b. For Foam Glass only:

1) No finish required for concealed installations above ceilings and within shafts.

2) Only field applied ASJ shall be used.

F. Cryogen piping, Indoor or Outdoor, Concealed or Exposed.

1. Insulation Material: Flexible Elastomeric.

2. Application Type: P2.

3. Finish:

a. Indoor: F8.

b. Outdoor: F3.

G. Hot Water, Steam, and Steam Condensate, Indoors, Concealed or Exposed.

1. Insulation Material: Rigid Fiberglass.

2. Application Type: P2.

3. Finish: F8.

H. Chilled Water, Steam, Steam Condensate, Cooling Condensate, Domestic Water, Piping Outdoors, Concealed or Exposed.

1. Insulation Material: Cellular Glass, with mitered section fittings only and field applied ASJ.

2. Application Type: P2.

3. Finish: F8 and F3.

4. Provide heat trace under insulation for hydronic services subject to freezing.

I. Engine Generators

1. Between engine generator and muffler:

a. Insulation material: Calcium silicate.

b. Application type: P1.

c. Finish: F3.

2. Engine generator muffler:

a. Insulation material: Calcium silicate.

b. Application type: E1.

c. Finish: F3.

1. For pipe sizes less than 1.5 inches and located within the conditioned envelope, insulation thicknesses may be reduced by 1 inch but never less than 1 inch. All reductions from the table above to be approved by the Engineer.

2. The above table is applicable to insulations in the conductivity ranges stated only. For insulation outside these conductivity ranges, the minimum thickness (T) shall be determined by the following calculation and the calculation submitted for acceptance:

$$T=r\{(1+t/r)^{K/k}-1\}$$

where T = Thickness

$r$ = Actual outside radius of pipe (in.)

$t$ = Insulation thickness per the above table

K = Conductivity of alternate material

k = Upper value of the Conductivity Range per the above table

**END OF SECTION**

# SECTION 23 08 00

# 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.

B. OPR, BoD, and BoD-HVAC documentation prepared by Owner and Architect contains requirements that apply to this Section.

1.2 SUMMARY

A. This Section includes requirements for commissioning the HVAC system and its subsystems and equipment. This Section supplements the general requirements specified in Division 01 Section "General Commissioning Requirements."

B. Related Sections include the following:

1. Division 01 Section "General Commissioning Requirements" for general requirements for commissioning processes that apply to this Section.

1.3 DEFINITIONS

A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of HVAC, electrical, communications, controls for HVAC systems, and other related systems.

B. BoD: Basis of Design.

C. BoD-HVAC: HVAC systems basis of design.

D. CxA: Commissioning Authority.

E. OPR: Owner's Project Requirements.

F. Systems, Subsystems, and Equipment: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, and equipment.

G. TAB: Testing, Adjusting, and Balancing.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. The following responsibilities are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Each Contractor:

1. Attend procedures meeting for TAB Work.

2. Certify that TAB Work is complete.

C. Mechanical Contractor:

1. Attend TAB verification testing.

2. Provide measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period.

D. HVAC Instrumentation and Control Contractor: With the CxA, review control designs for compliance with the OPR and BoD, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

E. TAB Contractor:

1. Contract Documents Review: With the CxA, review the Contract Documents before developing TAB procedures.

a. Verify the following:

1) Accessibility of equipment and components required for TAB Work.

2) Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.

3) Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.

4) Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.

5) Air and water flow rates have been specified and compared to central equipment output capacities.

b. Identify discontinuities and omissions in the Contract Documents.

c. This review of the Contract Documents by the TAB Subcontractor satisfies requirements for a design review report as specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

2. Additional Responsibilities: Participate in tests specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls" and

F. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.

2. Attend TAB verification testing.

1.5 COMMISSIONING DOCUMENTATION

A. The following are in addition to documentation specified in Division 01 Section "General Commissioning Requirements."

B. BoD HVAC: Owner will provide BoD-HVAC documents, prepared by Architect and approved by Owner, to the CxA and each Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

C. Test Checklists: CxA with assistance of Architect shall develop test checklists for HVAC systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. In addition to the requirements specified in Division 01 Section "General Commissioning Requirements," checklists shall include, but not be limited to, the following:

1. Calibration of sensors and sensor function.

2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.

3. Control sequences for HVAC systems.

4. Strength of control signal for each set point at specified conditions.

5. Responses to control signals at specified conditions.

6. Sequence of response(s) to control signals at specified conditions.

7. Electrical demand or power input at specified conditions.

8. Power quality and related measurements.

9. Expected performance of systems, subsystems, and equipment at each step of test.

10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.

11. Interaction of auxiliary equipment.

12. Issues log.

1.6 SUBMITTALS

A. The following submittals are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.

C. Certificate of Readiness: CxA shall compile certificates of readiness from each Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing.

D. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed. Certification shall include completed checklists provided by TAB Contractor as specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

E. Certified Pipe Cleaning and Flushing Report: CxA shall certify that pipe cleaning, flushing, hydrostatic testing, and chemical treating have been completed.

F. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates, and shall include them in systems manual and commissioning report.

G. Corrective Action Documents: CxA shall submit corrective action documents.

H. Certified TAB Reports: CxA shall submit verified, certified TAB reports.

## PART 2 - PRODUCTS (Not Used)

## PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Prerequisites for Testing:

1. Certify that HVAC systems, subsystems, and equipment have been completed, calibrated, and started; are operating according to the OPR, BoD, and Contract Documents; and that Certificates of Readiness are signed and submitted.

2. Certify that HVAC instrumentation and control systems have been completed and calibrated; are operating according to the OPR, BoD, and Contract Documents; and that pretest set points have been recorded.

3. Certify that TAB procedures have been completed, and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

4. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.

5. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shut down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

6. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.

7. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable, or failed. Repeat this test for each operating cycle that applies to system being tested.

8. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

9. Annotate checklist or data sheet when a deficiency is observed.

10. Verify equipment interface with monitoring and control system and TAB criteria; include the following:

    a. Supply and return flow rates for VAV and constant volume systems in each operational mode.

    b. Operation of terminal units in both heating and cooling cycles.

    c. Minimum outdoor-air intake in each operational mode and at minimum and maximum airflows.

    d. Building pressurization.

    e. Total exhaust airflow and total outdoor-air intake.

    f. Operation of indoor-air-quality monitoring systems.

11. Verify proper responses of monitoring and control system controllers and sensors to include the following:

    a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as

required. Retest malfunctioning devices and record results on checklist or data sheet.

b. Report deficiencies and prepare an issues log entry.

12. Verify that HVAC equipment field quality-control testing has been completed and approved. CxA shall direct, witness, and document field quality-control tests, inspections, and startup specified in individual Division 23 Sections.

B. Testing Instrumentation: Install measuring instruments and logging devices to record test data for the required test period. Instrumentation shall monitor and record full range of operating conditions and shall allow for calculation of total capacity of system for each mode of operation. For individual room cooling tests, provide temporary heaters to impose a cooling load indicated in BoD. Operational modes include the following:

1. Occupied and unoccupied.

2. Warm up and cool down.

3. Economizer cycle.

4. Emergency power supply.

5. Life-safety and safety systems.

6. Smoke control.

7. Fire safety.

8. Stair pressurization system.

9. Temporary upset of system operation.

10. Partial occupancy conditions.

11. Special cycles.

3.2 TAB VERIFICATION

A. TAB Contractor shall coordinate with CxA for work required in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" TAB Contractor shall copy CxA with required reports, sample forms, checklists, and certificates.

B. Each Contractor, HVAC Contractor, and CxA shall witness TAB Work.

C. TAB Preparation:

1. TAB Subcontractor shall provide CxA with data required for "Pre-Field TAB Engineering Reports" specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

a. CxA shall use this data to certify that prestart and startup activities have been completed for systems, subsystems, and equipment installation.

D. Ductwork Air Leakage Testing:

1. Architect will identify, for HVAC Subcontractor and CxA, portions of duct systems to have ductwork air leakage testing. Ductwork air leakage testing shall be performed according to Division 23 Section "Metal Ducts," and shall be witnessed by the CxA.

2. On approval of preliminary ductwork air leakage testing report, the CxA shall coordinate verification testing of ductwork air leakage testing. Verification testing shall include random retests of portions of duct section tests, reported in preliminary ductwork air leakage testing report. The HVAC Subcontractor shall perform tests using the same instrumentation (by model and serial number) as for original testing; the CxA shall witness verification testing.

E. Verification of Final TAB Report:

1. CxA shall select, at random, 10 percent of report for field verification.

2. CxA shall notify TAB Subcontractor 10 days in advance of the date of field verification; however, notice shall not include data points to be verified. The TAB Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item is defined as follows:

a. For all readings other than sound, a deviation of more than 10 percent.

1) For sound pressure readings, a deviation of 3 dB. (Note: Variations in background noise must be considered.)

4. Failure of more than 10 percent of selected items shall result in rejection of final TAB report.

F. If deficiencies are identified during verification testing, CxA shall notify the HVAC Subcontractor and Architect, and shall take action to remedy the deficiency. Architect shall review final tabulated checklists and data sheets to determine if verification is complete and that system is operating according to the Contract Documents.

G. CxA shall certify that TAB Work has been successfully completed.

3.3 TESTING

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

2. Alter set points when simulating conditions is not practical and when written approval is received from CxA.

3. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

C. Scope of HVAC Subcontractor Testing:

1. Testing scope shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. It shall include measuring capacities and effectiveness of operational and control functions.

2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. Detailed Testing Procedures: CxA, with HVAC Subcontractor, TAB Subcontractor, and HVAC Instrumentation and Control Subcontractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. HVAC Instrumentation and Control System Testing:

1. Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation for HVAC Controls" The CxA, HVAC Subcontractor, and the HVAC Instrumentation and Control Subcontractor shall collaborate to prepare testing plans.

2. CxA shall convene a meeting of appropriate entities to review test report of HVAC instrumentation and control systems.

F. Pipe cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in Division 23 piping Sections. HVAC Subcontractor shall prepare pipe system cleaning, flushing, and hydrostatic testing. CxA shall review and comment on plan and final reports. CxA shall certify that pipe cleaning, flushing, hydrostatic tests, and chemical treatment have been completed. 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 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.

G. Energy Supply System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of steam, hot-water systems and equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each equipment item and pipe section 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 system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

H. Heat-Generation System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of boilers, feedwater equipment, furnaces, and auxiliary equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings for each pipe sector showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

I. Refrigeration System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

J. HVAC Distribution System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems. Include HVAC terminal equipment and unitary equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

K. Vibration and Sound Tests: HVAC Subcontractor shall prepare testing plans to verify performance of vibration isolation and seismic controls. CxA shall witness and certify tests and inspections.

L. Prefunctional Tests Forms.

| AIR HANDLING UNIT # | OK | N/A |
|---|---|---|
| | | |
| FANS AND CASING SECTIONS: | | |
| 1. Spring isolators installed and not bottomed out. | | |
| 2. Motor rotation correct and free fan wheel rotation. | | |
| 3. Motor belts aligned and properly tensioned. | | |
| 4. Proper starter/VFD installed and labeled. | | |
| 5. Bearing races secured tight to fan shaft. | | |
| 6. Bearing grease cert fitting accessible and lubricated. | | |
| 7. All bolts, fasteners, and setscrews checked & tightened. | | |
| 8. At full speed, fans have no unusual noise or vibration. | | |
| 9. All safety guards are properly installed. | | |
| 10. Access doors close tightly, door gaskets installed. | | |
| 11. Casing/duct sealed with proper sealant. | | |
| 12. Proper insulation installed on casing and duct, and joints sealed. | | |
| 13. No evidence of air escaping unit or insulation ballooning w/fans on. | | |
| 14. No evidence of negative machine room pressure with fans operating | | |
| 15. Fan air volume measuring device installed. | | |
| 16. Duct static pressure control sensor installed at proper location. | | |
| 17. Duct safety static pressure sensor installed at proper location. | | |
| 18. Flex connection at fan discharge installed. | | |
| 19. Condensate drain trapped properly and run to floor drain. | | |
| 20. Manufacturer's required clearances for unit/components maintained. | | |
| 21. Dampers/actuators properly installed & close tightly. | | |
| 22. Damper linkage checked for binding, min. play & right blades. | | |
| 23. Required maintenance clearances maintained. | | |
| 24. Filters installed tightly and checked for no bypass. | | |
| 25. Metal spacers installed in filter rack. | | |
| 26. Filter manometers installed and calibrated. | | |
| 27. Air Handler control system operational. | | |
| | | |
| CHILLED WATER COILS: | | |
| 1. Coils clean and fins in good condition. | | |
| 2. No open area around coil for air bypass. | | |
| 3. Coil piped for counter flow. | | |
| 4. Chilled water pipe complete and piping properly supported. | | |
| 5. Chilled water pipe is properly insulated and labeled. | | |
| 6. Chilled water pipe pressure test complete and no leaks. | | |
| 5. Air bleed valves with caps installed. | | |
| 6. Strainers, drain valve, hose bib and cap installed. | | |
| 7. Dirt leg drain valve w/hose bib connections & caps installed. | | |
| 8. Piping, valves, and clearances accommodate coil removal. | | |
| 9. Balance valve properly installed. | | |

| | | |
|---|---|---|
| 10. Control valves properly installed. | | |
| 11. Pilot positioner installed on control valve actuator. | | |
| 12. Thermometers, PT plugs, pressure gages properly installed. | | |
| 13. Condensate pan, drain, and trap drains condensate properly. | | |
| | | |
| HEATING HOT WATER COILS: | | |
| 1. Coils clean and fins in good condition. | | |
| 2. Hot water pipe is complete and properly supported. | | |
| 3. Thermometers, PT plugs, pressure gages properly installed. | | |
| 4. Control valve installed if coil is w/o integral face & bypass dampers | | |
| 5. Two position valve installed if coil has integral face & bypass dampers | | |
| 6. Piping, valves, and clearances accommodate coil removal. | | |
| 7. Local in-line coil circulating pump installed & operable. | | |
| 8. Strainer, drain valve, hose bib and cap installed. | | |
| 9. Air bleed valves with caps installed. | | |
| | | |
| STEAM PRE-HEAT COILS: | | |
| 1. Steam valve assembly correctly installed. | | |
| 2. Condensate trapped correctly. | | |
| 3. Vacuum breaker installed. | | |
| 4. Piping and clearance permit coil removal. | | |

Air Handing Unit Comments:

Approvals:

| | |
|---|---|
| Date | Date |
| Mechanical Installer | Contractor |

| CHILLER # | OK | N/A |
|---|---|---|
| 1. Isolation valves installed. | | |
| 2. Pipes properly supported & not supported by chiller. | | |
| 3. Refrigerant relief vented outside and rain protected. | | |
| 4. Relief piping weight not bearing on rupture disc. | | |
| 5. Adequate space for tube pull. | | |
| 6. Unit has proper insulation type and thickness. | | |
| 7. Piping and insulation is complete and undamaged. | | |
| 8. Flow direction is indicated on chilled and condenser water lines. | | |
| 9. Insulation is installed where condensation may occur. | | |
| 10. Pressure gages are installed across evaporator and condenser. | | |
| 11. Thermometers are installed across evaporator and condenser. | | |
| 12. Evaporator and condenser heads removed, inspected, & trash free. | | |
| 13. Vibration isolation pads installed. | | |
| 14. Flow switches (or differential pressure transmitters) are installed. | | |
| 15. Drain valves piped to floor drain. | | |
| 16. Control wells installed. | | |
| 17. Oil cooler piped. | | |
| 18. Clearances have been maintained and piping is installed service. | | |
| 19. Chilled and Condenser water connections to chiller are correct. | | |
| 21. CT fans enabled when chiller is in auto mode. | | |
| 22. Factory representative start-up completed and documented. | | |

Chiller Comments:

Approvals:

| Date | Date |
|---|---|
| Mechanical Installer | Contractor |

| BOILER # | OK | N/A |
|---|---|---|
| 1. Unit is level. | | |
| 2. All bolts are tight. | | |
| 3. Clearance for maintenance and tube pull verified. | | |
| 4. Gas line connected. | | |
| 5. Gas pressure correct for burner. | | |
| 6. Gas pilot connected with ability to function when running on oil. | | |
| 7. Gas vents are installed correctly. | | |
| 8. Relief valves are correctly installed. | | |
| 9. Flue stack installed and complete with thermometer mounted. | | |
| 10. Verify external pipe connections are to the correct boiler opening. | | |
| 11. Verify PRV's are at the correct settings. | | |
| 12. Boiler feed piped with SCH 80 pipe and heavy-duty fittings. | | |
| 13. Boiler feed check valves installed correctly. | | |
| 14. Quick fill installed, pressure correct and back flow preventer in place | | |
| 15. Verify boiler has been boiled out properly. | | |
| 16. Boiler blow down valves installed. | | |
| 17. Boiler blow down piping correct type. | | |
| 18. Blow down receiver/cooler installed correctly. | | |
| 19. Blow down receiver installed. | | |
| 20. Surface blow down installed. | | |
| 21. Boiler water sampler installed. | | |
| 22. Chain valve operators installed. | | |
| 23. Flue drain installed. | | |
| 24. Oil lines connected. | | |
| 25. Oil filter installed on boiler, one per boiler. | | |
| 26. Chemical feed installed correctly | | |
| 27. Water softener supply to feed system installed & softeners operating. | | |
| 28. Factory representative start-up completed & documented. | | |

Boiler Comments:

Approvals:

| Date | Date |
|---|---|
| Mechanical Installer | Contractor |

| VAV/CV TERMINAL BOX # | OK | N/A |
|---|---|---|
| 1. At least 1 & 1/2 box inlet diameter of hard duct attached to box inlet. | | |
| 2. Run out from lateral is the correct size. | | |
| 3. Required clearance for servicing box. | | |
| 4. Correct piping package for reheat coil. | | |
| 5. Hot water return off top of coil. | | |
| 6. Electrical connections complete. | | |
| 7. Box properly located and supported. | | |

Terminal Box Comments:

Approvals:

| Date | Date |
|---|---|
| Mechanical Installer | Contractor |

| PCHW, SCHW, CW, HW PUMP # | OK | N/A |
|---|---|---|
| 1. Pressure gauge connection at pump inlet & outlet flanges. | | |
| 2. Single pressure gauge installed with cocks to select in or our pressure. | | |
| 3. Rotation correct. | | |
| 4. Strainer w/valve, hose bib and cap installed. | | |
| 5. Piping supported so that pump bears no pipe weight or lateral force. | | |
| 6. Drains piped to floor drain. | | |
| -7. Motor and pump coupling alignment verified. | | |
| 8. Cleanout of system piping complete. | | |
| 9. Suction diffuser start up strainer has been replaced w/ permanent strainer. | | |
| 10. Pumps properly grouted. | | |
| 11. Expansion tank connected to suction side of pump. | | |
| 12. Makeup water PRV set at correct pressure. | | |
| 13. VFD's installed. | | |

Pump Comments:

Approvals:

| Date | Date |
|---|---|
| Mechanical Installer | Contractor |

| STEAM & CONDENSATE PIPING | OK | N/A |
|---|---|---|
| 1. All take-offs installed at 45 or 90 degrees from top of pipe. | | |
| 2. Pipe expansion allowed for. | | |
| 3. Steam header and main properly trapped. | | |
| 4. Steam and condensate piped at proper slope. | | |
| 5. Condensate return piped with schedule 80 pipe & heavy fittings. | | |
| 6. Verify all traps are working. | | |
| 7. Verify steam to sterilizers is clean and dry. | | |

Steam & Condensate Comments:

Approvals:

| Date | Date |
|---|---|
| Mechanical Installer | Contractor |

| | Cooling Tower # | OK | N/A |
|---|---|---|---|
| 1 | Fan guard installed | | |
| 2 | Hand rail installed | | |
| 3 | Ladder installed. | | |
| 4 | Vibration isolation installed. | | |
| 5 | Motor alignment checked | | |
| 6 | Belts checked for proper alignment and tension | | |
| 7 | Means of gear box lubrication provided | | |
| 8 | Power is connected to VFD. | | |
| 9 | Means of disconnect provided. | | |
| 10 | VFD installed | | |
| 11 | Vibration safety switch installed and wired. | | |
| 12 | Basin water adjusted to proper level. | | |
| 13 | Equalizer line installed and has a valve installed in it. | | |
| 14 | Control valves installed in supply from tower, return to tower & bypass | | |
| 15 | Control wiring complete to valves, VFD and safety switches. | | |
| 16 | Make-up water available and set to proper level | | |
| 17 | Overflow Piped | | |
| 20 | Cooling Tower is free of debris and water is clear. | | |

Approvals:

Mechanical Signature: _____ Date: _____

Contractor Signature: _____ Date: _____

3.4 Functional Test Forms

| | | | |
|---|---|---|---|
| Project Name: | | Unit # | |
| Area Served: | | Date: | |

AHU Functional Performance Test w/Economizer

| Item | Table of Contents | |
|---|---|---|
| 1 | Start of Test Readings | |
| 2 | Valve Operating Tests | |
| 3 | Damper Binding Tests | |
| 4 | Static Pressure Controller | |
| 5 | AIR Flow Measuring Station Calibration | |
| 6 | Sensor Calibration | |
| 7 | SF and RF Airflow Measuring Device Synchronization | |
| 8 | Return Fan Volume Control | |
| 9 | Control Reaction Time Test | |
| 10 | Manual Freeze Stat Test | |
| 11 | High Static Safety test | |
| 12 | Low Static Safety Test | |
| 13 | Humidifier Sequence | |
| 14 | Fire Alarm Verification | |
| 15 | Final Set points | |
| 16 | Final Readings | |
| 17 | 24 hr Trend Test | |

Abbreviations and Definitions:

| | |
|---|---|
| AC | Actual – Current reading of sensor or location of actuator. |
| DAT | Discharge Air Temperature (F) |
| MAT | Mixed Air Temperature (F) |
| MC | Manually Command: Entered value for output device to position actuator to a set position. |
| MO | Manually Override: Entered value for input device or sensor such that the control sequences reacts as if the input device or sensor is currently sensing the entered value. |
| OAT | Outside Air Temperature (F) |
| RA | Return Air |
| RAT | Return Air Temperature (F) |
| RF | Return Fan |
| SA | Supply Air |
| SF | Supply Fan |
| SP | Set point: Value that control loop is trying to control to. |
| VI | Visually Inspect/Verify: Visually witness that action has taken place or device is properly working. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | Start of Test Readings | | | | | | |
| | Instructions: BAS contractor to record the following controls system point readings to document status of unit at the beginning of test. | | | | | | |
| | Sensor/Input Readings | | | Actuator/Output Positions | | | |
| | OAT | | ° F | Minimum OA Damper | | Opn/Clsd | |
| | OA Humidity | | %RH | Chilled Water Valve Position | | %Open | |
| | RAT | | ° F | SF VFD Speed | | Hz or % | |
| | RA Humidity | | %RH | RF VFD Speed | | Hz or % | |
| | MAT | | ° F | | | | |
| | Humidifier High Limit Reading | | %RH | | | | |
| | DAT | | ° F | | | | |
| | Duct Static Pressure | | In.W.G. | | | | |
| | Supply Fan CFM | | CFM | Design Supply CFM | | | |
| | Return CFM | | CFM | Design Return CFM | | | |
| | Outside Air Actual | | CFM | Design OA CFM | | | |

| | | | |
|---|---|---|---|
| 2 | Control Valve Test | | |
| 2a. | Chilled Water Valve (s) | | |
| | Verify Chilled water system is operating and under control. | | Y/N |
| | MC valve closed (0%) | | |
| | Measure Coil Water Differential Pressure | | In. W.G. |
| | VI valve closed? | | Y/N |
| | MC valve 5% open | | |
| | VI Valve stem starts to open? | | Y/N |
| | If NO: MC valve open in 2% increments (7%, 9%, 11%, 13%, and 15%) | | |
| | VI Valve starts to move. Record value that motion begins. | | % |
| | Value less than 15%? | | Y/N |
| | MC valve 90% open | | |
| | VI Valve motion? | | Y/N |
| | MC valve 100% open | | |

| | | | | |
|---|---|---|---|---|
| | VI additional stem movement from 90% to 100%? | | Y/N | |
| | VI Valve is 100% open. (Actuator, stem, valve, etc.)? | | Y/N | |
| 2b. | Manual close the chilled water valve serving unit. Clear all MC's and restore automatic control. | | | |
| Notes: | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| 3 | Damper Binding Test | | | |
| | MC VAV terminals served by this AHU to 100% Design Cooling CFM | | | |
| 3a. | Minimum Outside Air Damper Test (2-position) | | | |
| | MC Outside Air damper closed. | | | |
| | VI Minimum outside air damper is closed tightly. | | Y/N | |
| | MC Minimum Outside Air damper open | | | |
| | VI actuator and blades of the damper open fully. | | Y/N | |
| Notes: | | | | |
| | | | | |
| | | | | |
| 4 | Static Pressure Controller | | | |
| 4a. | Record location of Sensor: | | | |
| | Room Name : | | Plan Room Number: | |
| | Is pressure being sensed in area served by the AHU? | | Y/N | |
| 4b. | Record TAB recommended setpoint necessary to satisfy worse case air terminal. | | In. W.G. | |
| 4c. | Set the duct static pressure Setpoint to recommended value<br>MC VAV terminals served by this unit to Design Full Cooling CFM<br>Verify calibration by comparison to TAB contractors test Instrument measuring pressure between the same locations as the sensor. | | | |
| | | BAS Readings | Test Instrument Reading | |
| | Test 1 Differential Pressure | | | |
| | Test 2 Differential Pressure | | | |
| | Within Tolerance (Y/N) | | | |
| 4d. | Adjust setpoint down in increments of 0.2" to 0.4" below current setpoint, | | | |
| | Current Setpoint | | In. W.G. | |
| | | -0.2 | In. W.G. | |
| | 1st new Setpoint | | In. W.G. | |

| | | | |
|---|---|---|---|
| | VI Supply fan modulates down to new setpoint | | Y/N |

| | | | |
|---|---|---|---|
| | Adjust setpoint down to 0.4" below original setpoint, | -0.2 | In. W.G. |
| | 2nd new Setpoint | | In. W.G. |
| | VI Supply fan modulates down to new setpoint | | Y/N |
| | Set Static Pressure Setpoint to TAB recommendation (to serve worst case) | | In. W.G. |
| Notes: | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | | | |
|---|---|---|---|
| 5 | SF and RF Airflow Measuring Devices Calibration | | |
| 5a. | Fan Information<br>When CFM calculations are performed by BAS system and inlet probes are used, document the following information used in the CFM calculations. If factory calibrated flow transmitters are used attach the factory calibration information to completed report. | | |
| | Supply Fan Information | | |
| | Fan Inlet cone area | | ft2 |
| | Less probe obstruction | | ft2 |
| | Less fan shaft where applicable | | ft2 |
| | Flow Area | | ft2 |
| | Return Fan Information | | |
| | Fan Inlet cone area | | ft2 |
| | Less probe obstruction | | ft2 |
| | Less fan shaft where applicable | | ft2 |
| | Flow Area | | ft2 |
| 5c. | Verify CFM values of SA and RA are accurate by airflow Traverse where possible or other means if traverse will not be accurate. Specify method of measurement and record value. If multiple tests were required, and recalibrations performed, record only the final results after all recalibrations. | | See Note 1 |

| System | Method Used | BAS Readings | Traverse Reading |
|---|---|---|---|
| Supply Fan | | | |
| Return Fan | | | |

| | |
|---|---|
| | **Note 1.** Attach separate worksheet for each traverse showing the traverse detail measurements and calculations including each velocity pressure measurement taken in each traverse. |
| | Contact HCA Corporate Engineering if air flow traverse is more than 15% different than BAS measured air flow. |
| Notes: | |

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| 6 | Sensor Calibration | | |
| 6a. | MC VAV terminals served by this AHU to Design Full Cooling CFM<br>MC unit to 100% return.<br>Set Outside Air Setpoint (Supply CFM-Return CFM) to "0 CFM"<br>MC Minimum Outside Air Damper Completely Closed.<br>Let SF track duct sensor DP and MC RF to maintain 0" SP in mixed air plenum. | | |
| | VI all closed dampers for leakage. | | Y/N |
| | Note: If any leakage exists. Cover openings with polyethylene to insure that no air is leaving or entering the outside or relief dampers. | | |
| | Manual close the chilled water, heating water and steam valves serving unit. Verify coils are not affecting the air temperature. | | |
| 6b. | Verify calibration by comparison to TAB contractors test Instrument measuring temperature or humidity at the same location (unit position) as the sensor. Compare results of Test #1 and recalibrate BAS if necessary. If recalibration is done, perform Test #2 and record results to document sensor is within tolerance. *(Tolerance = +/- **0.5º** Degrees F. & +/- **5%** RH.)* | BAS Readings | Test Instrument Reading |
| | Return Air Temp Test #1 | | |
| | Return Air Temp Test #2 | | |
| | Sensor within tolerance? | | Y/N |
| | Return Air Humidity Test #1 | | |
| | Return Air Humidity Test #2 | | |
| | Sensor within tolerance? | | Y/N |
| | Mixed Air Temp Test #1 | | |
| | Mixed Air Temp Test #2 | | |
| | Sensor within tolerance? | | Y/N |
| | Supply Air High Limit Humidity Test #1 | | |
| | Supply Air High Limit Humidity Test #2 | | |
| | Sensor within tolerance? | | Y/N |
| | Discharge Air Temp Test #1 | | |
| | Discharge Air Temp Test #2 | | |
| | Sensor within tolerance? | | Y/N |
| Notes: | | | |
| | | | |

| | | | |
|---|---|---|---|
| 7 | SF and RF Airflow Measuring Device Synchronization | | |
| 7a. | With unit still in zero outside air mode (as above) record Supply Fan CFM and Return Fan CFM according to their respective airflow measuring stations. | | |
| | Supply Fan CFM | | CFM |
| | (-) Return Fan CFM | | CFM |
| | = Difference | | CFM |
| 7b. | If Difference is greater than 5% recalibrate the return fan airflow measuring station to equal supply fan CFM and re-record airflow measuring stations readings | | |
| | Supply Fan CFM | | CFM |
| | (-) Return Fan | | CFM |
| | = Difference | | CFM |
| 7c | Remove plastic and restore unit to Minimum Outside Air Mode | | |
| Notes: | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | | | |
|---|---|---|---|
| 8 | Return Fan Minimum Outside Air CFM | | |
| 8a. | MC VAV terminals served by this AHU to Design Full Cooling CFM | | |
| | MC unit in Minimum Outside Air Mode<br>Supply fan to automatically modulate speed to maintain duct static pressure.<br>Return fan to automatically modulate speed to maintain CFM offset | | |
| | Set Outside Air CFM offset to correct OA CFM | | |
| | CFM Offset Setpoint | | CFM |
| | Did RF VFD modulate to maintain minimum OA quantity | | Yes/No |
| | Supply Duct Static Pressure Reading (SPT-5) | | In. W.G. |
| | Supply Fan Speed | | % or Hz |
| | Return Fan Speed | | % or Hz |
| | Supply CFM per Air Flow Measuring Station | | CFM |
| | Return CFM per Air Flow Measuring Station | | CFM |
| | Outside Air CFM (SF-RF) | | CFM |
| 8c. | MC all VAV boxes served by this AHU to minimum CFM setting. | | |
| | Did RF VFD modulate to maintain minimum OA quantity | | Yes/No |
| | Supply Duct Static Pressure Reading (SPT-5) | | In. W.G. |
| | Supply Fan Speed | | % or Hz |
| | Return Fan Speed | | % or Hz |
| | Supply CFM per Air Flow Measuring Station | | CFM |
| | Return CFM per Air Flow Measuring Station | | CFM |
| | Outside Air CFM (SF-RF) | | CFM |
| 8d. | MC SA Fan and RA-Fan to "OFF" | | |
| | Supply Fan CFM (<50?) | | CFM |
| | Return Fan CFM (<50?) | | CFM |
| 8e. | Clear all MC's, MO's and restore automatic control. | | |
| Notes: | | | |
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| | | | |
| | | | |
| | | | |

| | | | |
|---|---|---|---|
| | | | |
| 9 | Control Reaction Time Test | | |
| 9a. | Set up Trend Log to record DAT, RAT, MAT and OAT temperatures every 1 minute for 15 minutes or until temperature stabilizes. | | |
| | Trend Logs Set? | | |
| | DAT | | Y/N |
| | RAT | | Y/N |
| | MAT | | Y/N |
| | OAT | | Y/N |
| 9b. | MC unit in Minimum Outside Air Mode<br>Change DAT SP to MAT-7 F (example: MAT=62 DAT SP = 62-7=55.) | | |
| | VI Time until DAT is stabilized within +/- 0.5 degrees of DAT SP. | | Minutes |
| | Is the time to stabilize less than a 15 minute period? | | Y/N |
| | Attach trend to completed procedure. | | Y/N |
| Notes: | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| 10 | Manual Reset Freeze Stat / Low Temp Detection | | |
| 10a. | VI Freeze stat is set at 34 ºF | | Y/N |
| 10b. | Use Ice Bag to activate low temperature/freeze stat, verify via BAS and Visual Inspection that: | BAS (√) | VI (√) |
| | SF shutdown | | |
| | RF shutdown | | |
| | Associated EF's shutdown | | |
| | Low temp alarm is initiated | | |
| | Minimum OA Damper Closed | | |
| | Chilled water valve opens | | |
| | Secondary chilled water pump is energized. | | |
| 10c. | Clear all MC's, MO's and restore automatic control. | | |
| Notes: | | | |
| | | | |
| | | | |

| | | | | |
|---|---|---|---|---|
| | | | | |
| 11 | HI Static Safety Switch ( If applicable ) | | | |
| 11a. | Record location of Sensor: | | | |
| 11b. | MC VAV terminals served by this AHU to Design Full Cooling CFM | | | |
| | Verify calibration by comparison to TAB contractors test Instrument measuring pressure between the same locations as the sensor. | Test Instrument Reading | | |
| | Static Pressure | | In. W.G | |
| 11c. | Verify setpoint | | | |
| | Static Pressure at full VAV cooling | | In. W.G | |
| | | +1.0 | In. W.G. | |
| | VI High static Safety setpoint = | | In. W.G. | |
| 11d. | Lower Static Safety Switch setpoint until it trips. | | | |
| | Supply fan discharge static when tripped | | In. W.G | |
| | VI AHU SF, RF and associated EF's shutdown | | Y/N | |
| | VI Steam humidifier valve closes and humidity process is disabled. | | Y/N | |
| 11e. | Return Static Safety Switch setpoint to it's original value and reset switch, | | | |
| | VI AHU Min OA damper modulates to open position | | Y/N | |
| | VI AHU SF & RF and associated EF's start. | | Y/N | |
| Notes: | | | | |
| | | | | |
| | | | | |

| | | | |
|---|---|---|---|
| 12 | LOW Static Safety Switch ( If applicable ) | | |
| 12a. | Record location of Sensor: | | |
| 12b. | MC VAV terminals served by this AHU to Design Full Cooling CFM | | |
| | Verify calibration by comparison to TAB contractors test Instrument measuring pressure between the same locations as the sensor. | Test Instrument Reading | |
| | Static Pressure | | In. W.G |
| 12c. | Verify setpoint | | |
| | Static Pressure at full VAV cooling | | In. W.G |
| | | -1.0 | In. W.G. |
| | VI High static Safety setpoint = | | In. W.G. |
| 12d. | Raise Static Safety Switch setpoint until it trips. | | |
| | Return fan inlet static when tripped | | In. W.G |
| | VI AHU SF, RF and associated EF's shutdown | | Y/N |
| | VI AHU min OA modulate to closed position | | Y/N |
| | VI Steam humidifier valve closes and humidity process is disabled. | | Y/N |
| 12e. | Return Static Safety Switch setpoint to it's original value and reset switch, | | |
| | VI AHU Min OA damper modulates to open position | | Y/N |
| | VI AHU SF & RF and associated EF's start. | | Y/N |
| Notes: | | | |
| | | | |

| | | | |
|---|---|---|---|
| 13 | Humidifier | | |
| 13a. | MO humidifiers enable temperature setpoint to 10 degrees greater than outside air temperature. | | |
| | OAT | | ºF |
| | | +10 | ºF |
| | New humidifiers enable temperature | | ºF |
| 13b. | MO the humidity setpoint to 90%. | | |
| | VI BAS commands Humidifier Steam Valve open | | Y/N |
| | VI Humidifier Steam Valve Opens | | Y/N |
| 13c. | MO supply duct humidity controlling/high limit setpoint to current duct RH – 10%. | | |
| | Current supply duct humidity | | %RH |
| | | -10 | %RH |
| | New supply duct controlling/high limit setpoint | | %RH |
| | VI BAS commands Humidifier Steam Valve closed | | Y/N |
| | VI Humidifier Steam Valve starts to close | | Y/N |
| | Duct humidity when valve begins to close | | %RH |
| 13d. | MO high limit alarm setpoint down in 5% increments: | | |
| | High limit alarm activates | | Y/N |
| | At what alarm setpoint | | %RH |
| | VI Steam valve closes. | | Y/N |
| 13e. | Return Humidifier controlling humidity setpoint to original value. | | |
| | Return Humidifier alarm setpoint to original value. | | |
| | MO Humidifier lockout setpoint to 5 degrees less than actual outside temperature | | |
| | Current OAT | | ºF |
| | | -5 | ºF |
| | New Humidifier lockout setpoint | | ºF |
| | VI Steam valve closes. | | Y/N |
| 13f. | Return Humidifier lockout setpoint to original value. | | |
| Notes: | | | |
| | | | |
| | | | |
| | | | |
| | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14 | Fire Alarm | | | | | | | |
| 14a. | Initiate Fire alarm signal to BAS (can close/open fire alarm interface contact.) | | | | | BAS | VI | |
| | | | | | | (√) | (√) | |
| | SF shutdown | | | | | | | |
| | RF shutdown | | | | | | | |
| | Associated EF's shutdown | | | | | | | |
| | FS/D's associated with AHU close after a 10 second delay. | | | | | | | |
| | Economizer OA Damper Closed | | | | | | | |
| 14b. | MO OAT to 40 F. | | | | | | | |
| | Preheat Pump (PHP) Starts | | | | | | Y/N | |
| 14c. | Initiate Fire alarm reset signal to BAS (can close/open fire alarm interface contact.) | | | | | BAS | VI | |
| | | | | | | (√) | (√) | |
| | FS/D's associated with AHU open. | | | | | | | |
| | After 10 second delay SF starts | | | | | | | |
| | RF starts | | | | | | | |
| | Associated EF's start | | | | | | | |
| Notes: | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| 15 | Final Set Points: | | | | | | | |
| | Record the following set points from the controls system | | | | | | | |
| | DAT | | ° F | Duct Static Pressure | | In. W. G. | | |
| | Controlling Limit/High Limit Hu-midistat | | %RH | Outside Air Offset | | CFM | | |
| | | | | Economizer Lockout Temp | | | | |
| | | | | Humidifier Lock-out Outside Air Temperature Setpoint | | ° F | | |
| Notes: | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | Final Readings | | | | | | |
| | Instructions: BAS contractor to record the following controls system point readings to document status of unit at the end of test. | | | | | | |
| | Sensor/Input Readings | | | Actuator/Output Positions | | | |
| | OAT | | ° F | Minimum OA Damper | | Open/ | |
| | OA Humidity | | %RH | Humidifier Valve Position | | %Open | |
| | RAT | | ° F | Chilled Water Valve Position | | %Open | |
| | RA Humidity | | %RH | SF VFD Speed | | Hz or % | |
| | MAT | | ° F | RF VFD Speed | | Hz or % | |
| | Humidifier High Limit Reading | | %RH | | | | |
| | DAT | | ° F | | | | |
| | Duct Static Pressure | | In.W.G. | | | | |
| | Supply Fan CFM | | CFM | | | | |
| | Return CFM | | CFM | | | | |
| | Outside Air Actual | | CFM | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | 24-hr Total Unit Trends | | | | | | |
| 17a. | Set up Trend Log to record the following required points once every 1 minute preferred or a minimum of once every 5 minutes for 24 Hours. Data shall be in electronic tabulated form in excel and transmitted to engineer for review. Prepare and attach a copy of the following graphs | | | | | | |
| | Temperatures: | | | | | | |
| | OAT | MAT | PHT | DAT | DATSP | RAT | |
| | Humidity's: | | | | | | |
| | OA %RH, | RA RH% | Humidifier HI Limit Sensor | | | RHSetpoint | |
| | Damper Positions: | | | | | | |
| | Min OA | Econo OA | Return Damper | Relief Damper | | | |
| | Valve Positions | | | | | | |
| | Chilled Water | Pre-Heat | Humidifier | | | | |
| | CFM's | | | | | | |
| | Supply | Return | OA(Software Control Value) | | | | |
| | %Speed of VFD's: | | | | | | |
| | Supply Fan | Return | | | | | |
| | Static Pressures: | | | | | | |
| | Duct SP | SP Setpoint | | | | | |
| | | | | | | | |
| | Trend Start Date and Time | | | | | | |
| | Trend End Date and Time | | | | | | |
| | Graphs attached | | | | | | Y/N |
| Notes: | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | | | |
|---|---|---|---|
| Proj. Name: | | | |
| Printout Date: | Wednesday, January 04, 2006 | | |
| | | | |
| | | | |
| Primary Chilled Water System | | | |
| PCHP-1 | | | |
| Initial Setup | | | |
| All Equipment Off? | | | Y/N |
| Does BAS indicate PCHP-1 status OFF? | | | Y/N |

| | | | | | |
|---|---|---|---|---|---|
| | | | Does BAS indicate Chiller - 1 Isolation Valve V-CH-1 CLOSED? | | Y/N |
| | | Open Chiller - 1 Isolation Valve V-CH-1 | | | |
| | | | Does BAS indicate Chiller - 1 Isolation Valve V-CH-1 OPEN? | | Y/N |
| | | Start PCHP-1 IN HAND | | | |
| | | | Does BAS indicate pump status ON | | Y/N |
| | | Close pump Discharge Valve | | | |
| | | | Does BAS indicate pump status OFF | | Y/N |
| | | | Pump Shutoff Head | | Ft.WG |
| | | Switch starter to Auto | | | |
| | | BAS to command pump ON | | | |
| | | | Does Pump start? | | Y/N |
| | | | Does BAS indicate pump status OFF | | Y/N |
| | | Open PCHP-1 discharge valve | | | |
| | | | Does BAS indicate pump status ON | | Y/N |
| | | | Pump Head | | Ft.WG |
| | | | Pump GPM from submitted curve | | GPM |
| | | | Flow Meter FM-CHW-1 Reading | | GPM |
| | | | Chiller-1 Pressure Drop | | Ft.WG |
| | | | Submitted Chiller Pressure Drop | | Ft.WG |
| | | | Submitted Chiller Flow GPM | | GPM |
| | | | Chiller Flow GPM | | GPM |
| | | | Chiller Flow % | | % |
| | | Calibrate Temperature Sensors | | | |
| | | | TAB Temperature Reading | | ºF |
| | | | TAB Temperature Reading Location | | Y/N |
| | | | Primary CHW Supply Temp TT-CHW-1 | | ºF |
| | | | Primary CHW Return Temp TT-CHW-2 | | ºF |
| | | | Decoupler Temp TT-CHW-5 | | ºF |
| | | Leave Pump Running in Auto | | | |
| | PCHP-2 | | | | |
| | | | Does BAS indicate PCHP-2 status OFF? | | Y/N |
| | | | Does BAS indicate Chiller - 2 Isolation Valve V-CH-2 CLOSED? | | Y/N |
| | | Open Chiller - 2 Isolation Valve V-CH-2 | | | |
| | | | Does BAS indicate Chiller - 2 Isolation Valve V-CH-1 OPEN? | | Y/N |
| | | Start PCHP-2 IN HAND | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Does BAS indicate pump status ON | | Y/N |
| | | Close pump Discharge Valve | | | |
| | | | Does BAS indicate pump status OFF | | Y/N |
| | | | Pump Shutoff Pressure | | Ft.WG |
| | | Switch starter to Auto | | | |
| | | BAS to command pump ON | | | |
| | | | Does Pump start? | | Y/N |
| | | | Does BAS indicate pump status OFF | | Y/N |
| | | Open discharge valve | | | |
| | | | Does BAS indicate pump status ON | | Y/N |
| | | | Pump PCHP-1 | | Ft.WG |
| | | | Pump PCHP-2 | | Ft.WG |
| | | | Pump GPM from submitted curve | | GPM |
| | | | Flow Meter FM-CHW-1 Reading | | GPM |
| | | | Chiller-1 Pressure Drop | | Ft.WG |
| | | | Chiller-2 Pressure Drop | | Ft.WG |
| | | Leave Pump Running in Auto | | | |
| Condenser Water Systems | | | | | |
| | CWP-1 | | | | |
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | | Does BAS indicate CH - 1 Isolation Valve V-CW-1 CLOSED? | | Y/N |
| | | Open Chiller - 1 Isolation Valve V-CW-1 | | | |
| | | | Does BAS indicate Chiller - 1 Isolation Valve V-CW-1 OPEN? | | Y/N |
| | | | Does BAS indicate CT - 1 Return Valve V-CT-1 CLOSED? | | Y/N |
| | | Open CT-1 Return Isolation Valve | | | |
| | | | Does BAS indicate CT - 1 Return Valve V-CT-1 OPEN? | | Y/N |
| | | | Does BAS indicate CT - 1 Supply Valve V-CT-1 CLOSED? | | Y/N |
| | | Open CT-1 Supply Isolation Valve | | | |
| | | | Does BAS indicate CT - 1 Supply Valve V-CT-1 OPEN? | | Y/N |
| | | Start pump in HAND | | | |
| | | | Does BAS indicate pump status ON? | | Y/N |
| | | Close pump Discharge Valve | | | |
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | | Pump Design Head? | | Ft.WG |

| | | | | | |
|---|---|---|---|---|---|
| | | | Pump Design GPM? | | Ft.WG |
| | | | Pump Shutoff Suction Pressure | | Psi |
| | | | Pump Shutoff Discharge Pressure? | | Psi |
| | | Switch starter to Auto | | | |
| | | BAS to command pump ON | | | |
| | | | Does Pump start? | | Y/N |
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | Open discharge valve | | | |
| | | | Does BAS indicate pump status ON? | | Y/N |
| | | | Pump Suction Pressure | | Psi |
| | | | Pump Discharge Pressure | | Psi |
| | | | Pump GPM from submitted curve | | GPM |
| | | | Chiller-1 Pressure Drop | | Ft.WG |
| | | | Submitted Chiller Pressure Drop | | Ft.WG |
| | | | Submitted Chiller Flow GPM | | GPM |
| | | Calibrate Temperature Sensors | | | |
| | | | TAB Temperature Reading | | ºF |
| | | | TAB Temperature Reading Location | | ºF |
| | | | Common CW Supply Temp TT-CW-1 | | ºF |
| | | | Common CW Return Temp TT-CW-2 | | ºF |
| | CWP-2 | | | | |
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | | Does BAS indicate CH - 2 Isolation Valve V-CW-1 CLOSED? | | Y/N |
| | | Open Chiller - 2 Isolation Valve V-CW-2 | | | |
| | | | Does BAS indicate Chiller - 2 Isolation Valve V-CW-2 OPEN? | | Y/N |
| | | | Does BAS indicate CT - 2 Return Valve V-CT-1 CLOSED? | | Y/N |
| | | Open CT-2 Return Isolation Valve | | | |
| | | | Does BAS indicate CT - 2 Return Valve V-CT-2 OPEN? | | Y/N |
| | | | Does BAS indicate CT - 2 Supply Valve V-CT-2 CLOSED? | | Y/N |
| | | Open CT-2 Supply Isolation Valve | | | |
| | | | Does BAS indicate CT - 2 Supply Valve V-CT-2 OPEN? | | Y/N |
| | | Start pump in HAND | | | |
| | | | Does BAS indicate pump status ON? | | Y/N |
| | | Close pump Discharge Valve | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | | Pump Shutoff Suction Pressure? | | Psi |
| | | | Pump Shutoff Discharge Pressure? | | Psi |
| | | Switch starter to Auto | | | |
| | | BAS to command pump ON | | | |
| | | | Does Pump start? | | Y/N |
| | | | Does BAS indicate pump status OFF? | | Y/N |
| | | Open discharge valve | | | |
| | | | Does BAS indicate pump status ON? | | Y/N |
| | | | Pump Suction Pressure | | Psi |
| | | | Pump Discharge Pressure | | Psi |
| | | | Chiller-1 Pressure Drop | | Ft.WG |
| | | | Chiller-2 Pressure Drop | | Ft.WG |
| | | Leave Pump Running in Auto | | | |
| | CT-1 | | | | |
| | | | Does BAS indicate tower status OFF? | | Y/N |
| | | Place VFD in HAND at Min, Speed | | | |
| | | | Does BAS Status = ON | | Y/N |
| | | | Drive Min. Speed? | | Hz |
| | | | BAS Speed Feedback? | | % |
| | | Place VFD in HAND at Max, Speed | | | |
| | | | BAS Speed Feedback? | | % |
| | | Place VFD in AUTO | | | |
| | | Command Drive on at Min. Speed | | | |
| | | | Drive Min. Speed? | | % |
| | | | BAS Speed Feedback? | | % |
| | | Leave Drive in Auto, BAS to set to Auto | | | |
| | CT-2 | | | | |
| | | | Does BAS indicate tower status OFF? | | Y/N |
| | | Place VFD in HAND at Min, Speed | | | |
| | | | Does BAS Status = ON | | Y/N |
| | | | Drive Min. Speed? | | Hz |
| | | | BAS Speed Feedback? | | % |
| | | Place VFD in AUTO | | | |
| | | Command Drive on at Min. Speed | | | |
| | | | Drive Min. Speed? | | Hz |
| | | | BAS Speed Feedback? | | % |
| | | Leave Drive in Auto, BAS to set to Auto | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Secondary Chilled Water Pumping System | | | | | | | |
| | | Command All AHU CHW Valves 100% Open | | | | | |
| | SCHP-1 | | | | | | |
| | | | Does BAS indicate pump status OFF? | | | | Y/N |
| | | Place VFD in HAND at Min, Speed | | | | | |
| | | | Does BAS Status = ON | | | | Y/N |
| | | | Drive Min. Speed? | | | | Hz |
| | | | BAS Speed Feedback? | | | | % |
| | | Place VFD in AUTO | | | | | |
| | | Command Drive on at Min. Speed | | | | | |
| | | | Drive Min. Speed? | | | | Hz |
| | | | BAS Speed Feedback? | | | | % |
| | | | BAS Bypass Status = OFF? | | | | Y/N |
| | | Place Drive in Bypass | | | | | |
| | | | BAS Bypass Status = ON? | | | | Y/N |
| | | Turn Off Pump/Place in AUTO | | | | | |
| | SCHP-2 | | | | | | |
| | | | Does BAS indicate pump status OFF? | | | | Y/N |
| | | Place VFD in HAND at Min, Speed | | | | | |
| | | | Does BAS Status = ON | | | | Y/N |
| | | | Drive Min. Speed? | | | | Hz |
| | | | BAS Speed Feedback? | | | | % |
| | | Place VFD in AUTO | | | | | |
| | | Command Drive on at Min. Speed | | | | | |
| | | | Drive Min. Speed? | | | | Hz |
| | | | BAS Speed Feedback? | | | | % |
| | | | BAS Bypass Status = OFF? | | | | Y/N |
| | | Place Drive in Bypass | | | | | |
| | | | BAS Bypass Status = ON? | | | | Y/N |
| | | Turn Off Pump/Place in AUTO | | | | | |
| | CHW Differential Pressure Sensor/Controls | | | | | | |
| | | | Current DP Setpoint | | | | PSI |
| | | Set DP Setpoint to be Low | | | | | |
| | | | New DP Setpoint | | | | PSI |
| | | Set SCHP-1 as Lead | | | | | |
| | | Start Pumping System | | | | | |
| | | | Did SCHP-1 Start? | | | | Y/N |
| | | | What Speed did pump settle at? | | | | % |

| | | | | | |
|---|---|---|---|---|---|
| | | Turn Off Lead Pump at VFD | | | |
| | | | Did Lag Pump Start? | | Y/N |
| | | | How long till Lag pump started? | | Sec. |
| | | Turn lead pump back on at VFD | | | |
| | | | Did lead pump restart? | | Y/N |
| | | | Did Lag Pump Stop? | | Y/N |
| | | Swap lead/lag | | | |
| | | | Did New Lead Pump Start? | | Y/N |
| | | | Did New Lag Pump Stop? | | Y/N |
| | | Set DP Setpoint High | | | |
| | | | Did Lead Pump Speed Up? | | Y/N |
| | | | Did Lag Pump Start? | | Y/N |
| | | | How long till Lag pump started? | | Min. |
| | | | What Speed did Lag pump start at? | | % |
| | | | Did Pumps modulate together? | | Y/N |
| | | Set DP Setpoint Low | | | |
| | | | New DP Setpoint | | Psi |
| | | | Did Pumps modulate slower together? | | Y/N |
| | | | At what speed did Lag pump stop? | | % |
| | | | How long till Lag pump stopped? | | Min. |
| | System Reset | | | | |
| | | Turn off all Equipment | | | |
| | | Place all starters in Auto | | | |
| | | Place all VFD's in Auto | | | |
| Starting Main Chilled Water System | | | | | |
| | | Disable chillers at local panel to ensure compressors don't run | | | |
| | Verify Lead Equipment | | | | |
| | | | Verify CWP-1 is Lead? | | Y/N |
| | | | Verify CH-1 is Lead? | | Y |
| | | | Verify PCHP-1 is Lead? | | Y/N |
| | | | Verify CT-1 is Lead? | | Y/N |
| | | Set All AHU CHW Valves Closed | | | |
| | | Enable Chilled water system | | | |
| | | | Did V-CH-1 Open? | | Y/N |
| | | | Did V-CW-1 Open? | | Y/N |
| | | | Did V-CT-1 Supply Open? | | Y/N |
| | | | Did V-CT-1 Return Open? | | Y/N |

| | | | | | |
|---|---|---|---|---|---|
| | | | Did PCHP-1 Start | | Y/N |
| | | | Did SCHP-1 Start? | | Y/N |
| | | | Did CWP-1 Start? | | Y/N |
| | | | Did Start Command go to Chiller CH-1? | | Y/N |
| | | | Did CT-1 Fan Start | | Y/N |
| | | Get Temperatures | | | |
| | | Get Flows | | | |
| | | | FM-CHW-1 | | GPM |
| | | | FM-CHW-2 | | GPM |
| | | Get Speeds | | | |
| | | Turn off PCHP-1 by disconnect | | | |
| | | | Did Lag Start? | | Y/N |
| | | | Approx. Time Until Lag Start | | Sec. |
| | | Turn off CWP-1 by disconnect | | | |
| | | | Did Lag Start? | | Y/N |
| | | | Approx. Time Until Lag Start | | Min. |
| | | Turn off CT-1 by disconnect | | | |
| | | | Did Lag Start? | | Y/N |

A. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.

2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

B. Testing Reports:

1. Reports shall include measured data, data sheets, and a comprehensive summary describing the operation of systems at the time of testing.

2. Include data sheets for each controller to verify proper operation of the control system, the system it serves, the service it provides, and its location. For each controller, provide space for recording its readout, the reading at the controller's sensor(s), plus comments. Provide space for testing personnel to sign off on each data sheet.

3. Prepare a preliminary test report. Deficiencies will be evaluated by Architect to determine corrective action. Deficiencies shall be corrected and test repeated.

4. If it is determined that the system is constructed according to the Contract Documents, Owner will decide whether modifications required to bring the performance of the system to the OPR and BoD documents shall be implemented or if tests will be accepted as submitted. If corrective Work is performed, Owner will decide if tests shall be repeated and a revised report submitted.

**END OF SECTION**

# SECTION 23 09 00

# INSTRUMENTATION AND CONTROL FOR HVAC

## PART 1 - GENERAL

1.1 SUMMARY

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

B. Related Sections include the following:

1. Division 01 "General Commissioning Requirements" for the commissioning process where controls personnel are to actively participate.

2. Division 23 Section "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.

3. Division 23 Section "Outdoor Modular AHUs" for additional requirements.

4. Division 23 Section "Outdoor Custom AHUs" for additional requirements.

5. Division 23 Section "Dedicated Outdoor-Air Units" for additional requirements.

1.2 DEFINITIONS

A. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

B. 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 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 options specified by BACnet that are implemented in a device.

C. 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.

D. 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.

E. 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.

F. DDC: Direct digital control.

G. EPO: Emergency power off. An emergency push-button used to de-energize connected power equipment. EPOs are typically installed at room egresses and have a guard to prevent accidental activation.

H. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

I. 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.

J. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.

2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.

3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.

4. LonWorks: Network technology developed by Echelon.

5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.

6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.

7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."

8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.

9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark International for configuration properties.

10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").

11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."

12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.

13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.

14. User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.

15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

K. 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.

L. Modbus TCP/IP: An open protocol for exchange of process data.

M. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

N. MTBF: Mean time between failures.

O. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicate on peer-to-peer network for transmission of global data.

P. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Q. PC: Personal computer.

R. Peer to Peer: Networking architecture that treats all network stations as equal partners.

S. PID: Proportional plus integral plus derivative.

T. RTD: Resistance temperature detector.

U. UPS: Uninterruptible power supply.

V. USB: Universal Serial Bus.

W. WAGES: Water, Air, Gas, Electric, Steam. Used to describe a panel with a Modbus IP level of communication for interface to HCA Corporate, FacilitiGroup, Energy Service Center.

1.3 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 degrees F.

b. Water Flow: Plus or minus 5 percent of full scale.

c. Water Pressure: Plus or minus 2 percent of full scale.

d. Space Temperature: Plus or minus 1 degrees F.

e. Ducted Air Temperature: Plus or minus 1 degrees F.

f. Outside Air Temperature: Plus or minus 2 degrees F.

g. Dew Point Temperature: Plus or minus 3 degrees F.

h. Temperature Differential: Plus or minus 0.25 degrees F.

i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.

k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

l. Airflow (Terminal): Plus or minus 10 percent of full scale.

m. Air Pressure (Space): Plus or minus 0.01-inch wg.

n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

o. Carbon Monoxide: Plus or minus 5 percent of reading.

p. Carbon Dioxide: Plus or minus 50 ppm.

q. Electrical: Plus or minus 5 percent of reading.

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: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical

characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. 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.

4. Control Valves: Provide a schedule with line size, valve inlet size, design flow, Cv, pressure drop through the controlled coil, and valve authority.

C. 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. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

3. Wiring Diagrams: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.

   b. Schematic diagrams and floor plans for field sensors and control hardware.

   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

    c. Written description of sequence of operation including schematic diagram.

    d. Points list.

D. Data Communications Protocol Certificates: Certify that each proposed DDC system component, including workstations, diagnostic units, unitary and assembled controllers, and all informational and signal processes, complies with ASHRAE 135.

E. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

F. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Field quality-control test reports.

1.6 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 01 78 23 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.

b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

c. As-built versions of submittal Product Data.

d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.

f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.

2) Perform preventive maintenance and calibration.

3) Debug hardware problems.

4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.

j. List of recommended spare parts with part numbers and suppliers.

k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

m. Licenses, guarantees, and warranty documents.

n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

o. Owner training materials.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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. Provide appropriate controls personnel and support for the test and balance process.

D. Provide appropriate controls personnel and support for the commissioning process as defined in Division 01.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

F. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

G. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

H. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

I. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.10 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. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, and thermostat.

2. Maintenance Materials: One thermostat adjusting key(s) per floor or 50,000 sqft of total conditioned space, whichever is greater.

3. Maintenance Materials: One pneumatic thermostat test kit.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Schneider Electric Struxureware

2.2 GENERAL REQUIREMENTS

A. Provide labor, materials, equipment, tools and services, and perform operations required for, and reasonably incidental to, the provision, installation and extension of the existing building automation and Control System (FMS) including all related systems and accessories.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

C. System points lists included in the Documents are intended to show the desired alarm, monitoring and control points. Add any control points necessary and as required to accomplish the sequence of operations.

D. The FMS/DDC shall use BACNet/IP protocol capable of communicating over an Ethernet system. It shall be capable of residing on the corporate enterprise WAN/LAN by having an assigned IP address. FMS/DDC systems are required to permit a remote user with password access, monitor points and issue basic commands over the corporate enterprise WAN/LAN using a PC type terminal without the need for proprietary FMS/DDC software. The system front end and database shall reside on an Owner furnished server not a PC. Provide a new laptop with FMS software to the facility when a new FMS is installed or there is a major upgrade to the system.

E. Connection by remote FMS to be accommodated by allowing polling of FMS parameters over an open protocol such as BACnet and Modbus TCP.

F. Provide a UPS with a minimum of 15 minute backup for all building controllers to prevent disruption during a temporary loss of power, including where the loss of memory, program content, or control function may result.

G. Provide a UPS with a minimum of 15 minute backup for all AHU damper actuators to prevent closure during a temporary loss of power.

H. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

I. The control system shall also include a paging feature with telephone/email alerts to selected personnel for critical alarms as defined by Owner.

J. The control system shall be connected to the facility LAN and shall permit at least 4 simultaneous users to access the system over the LAN, based on password level, monitor parameters, change set points, set up trends, or start/stop controlled equipment. A remote user shall have this capability without having the system data base loaded on his/her remote computer

K. All terminal box controller parameters shall be mapped to the front end of the FMS.

L. For AHUs, each individual operating state shall have an individual PID control loop for that state.

M. Dynamic animated color graphic displays

1. Color graphic floor plan displays, and system schematics for each piece of mechanical equipment (including air handling units, variable air volume boxes, fan coils, unit ventilators, cabinet heaters, exhaust fans, fin tube radiation, chilled water systems, hot water boiler systems, and so forth) shall be provided, as specified in the point lists of the Documents, in order to optimize system performance analysis, speed alarm recognition, and simplify user interaction. Configure the color graphics and plot all associated control/monitoring points on the screen. Copies of all color graphics screens shall be provided as color printouts to the engineer for approval.

2. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or test-based commands. Floor plans shall display room numbers and each zone shall be color-coded. The operator shall be able to point and click on a room or zone of rooms (in the case of an air handler that serves more than one zone). The room or zone will display an animated flow diagram of the mechanical equipment that serves that zone, with all control and monitoring points associated with that piece of equipment, including setpoints. Setpoints shall be overridden or modified from this screen.

3. Dynamic Animated Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention. Damper and valve positions, air and water flow shall be animated and shall represent actual, current conditions.

4. System Performance Analysis Screens: System performance analysis screens shall be provided for the major mechanical systems (such as air handlers, chillers, boilers, and so forth.). For each of these systems, the screen shall be split into quadrants, simultaneously displaying the following data:

    a. Quadrant 1. – Dynamic animated flow diagrams.

    b. Quadrant 2. – All analog values associated with the mechanical system shall be graphed on an X-Y axis graph. Five-minute samples for the last twenty-four hour period shall plotted. Scaling shall be automatic.

    c. Quadrant 3. – Text sequence of operations from engineering as-built submittals.

    d. Quadrant 4. – Space temperature summaries from each zone being served by mechanical system.

5. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting Work in progress.

6. Alarm Annunciation: Any point in a state of alarm shall change the color of its symbol to red until it is no longer in alarm.

7. AHU Summary Graphic Screen: An AHU summary graphic screen shall be provided for economizer and non economizer AHU's as follows:

    a. AHU's without economizer cycles shall include a summary graphic screen including the following information:

        1) Air Handling Unit

            a) AHU number

            b) Supply air temperature

            c) Supply air temperature setpoint

            d) Supply air cfm setpoint

            e) Total terminal box airflow

            f) Chilled water valve position in %

g) Return air temperature

h) Return air humidity in %

i) Outside air temperature

j) Outside air humidity

2) Chilled Water Secondary System

a) Chilled water supply temperature

b) Chilled water return temperature

c) Chilled water flow in gpm

d) Building load in tons

e) Chilled water system differential pressure

f) Chilled water system differential pressure setpoint

g) Each chilled water pump speed in %

3) Chillers

a) Each chillers chilled water supply temperature.

b. AHU's with economizer cycles shall include a summary graphic screen including the following information:

1) Air Handling Unit

a) AHU number

b) Supply air temperature

c) Supply air temperature setpoint

d) Return air temperature

e) Outside air temperature

f) Outside air humidity

g) Mixed air temperature

2) Outside Air

a) Outside air cfm setpoint

b) Outside air cfm measured

c) Return fan speed %

d) Supply Fan speed %

e) Supply static pressure setpoint

f) Supply static pressure actual

3) Dampers

a) Economizer damper open position %

N. Systems integration/FMS specific requirements

1. FMS Remote Access: The Facility Management System provided shall include the capability for multiple users to access the FMS simultaneously from remote locations via the Internet. Internet access shall be accomplished by use of standard Internet browser software applications such as Netscape Navigator ® or Microsoft Internet Explorer ® and shall not require the use of proprietary access software. Interface shall be to the entire FMS and provide capability to monitor all I/O and adjust parameters.

2. Open Systems Integration: VFD Integrator Interface

a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the VFD manufacturer's control panel.

b. Coordinate with the VFD manufacturer to provide a functional data communications connection.

c. All data supported by the VFD communication protocol shall be mapped into the supervisory DDC controller's database and shall be displayed on data screens at the Operator Workstation and shall be transparent to the operator.

d. Furnish a BACnet communications interface as required by the VFD manufacturer.

e. Provide all communications and power wiring and gateway panel installation for the DDC system. The VFD manufacturer shall provide all hardware for connection of the manufacturer's processor.

f. Provide all hardware and software required for the VFD manufacturer's gateway interface.

3. Open Systems Integration: Chiller Integrator Interface

a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the chiller manufacturer's chiller control panel.

b. Coordinate with the chiller manufacturer to provide a functional data communications connection.

c. All data supported by the chiller communication protocol shall be mapped into the supervisory DDC controller's database and shall be displayed on a chiller data screen at the Operator Workstation and shall be transparent to the operator.

d. Furnish a BACnet communications interface as required by the chiller manufacturer.

e. Provide all communications and power wiring and gateway panel installation for the DDC system. The chiller manufacturer shall provide all hardware for connection of the manufacturer's processor.

f. Provide all hardware and software required for the chiller manufacturer's gateway interface.

4. Open Systems Integration: Boiler Integrator Interface

a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the boiler manufacturer's Master Boiler Controller Control Panel.

b. Coordinate with the boiler manufacturer to provide a functional data communications connection.

c. All data supported by the boiler communication protocol shall be mapped into the supervisory DDC controller's database and shall be displayed on a boiler data screen at the Operator Workstation and shall be transparent to the operator.

d. Furnish BACnet communications interface as required by the chiller manufacturer.

e. Provide all communications and power wiring and gateway panel installation for the DDC system. The boiler manufacturer shall provide all hardware for connection of the manufacturer's processor.

f. Provide all hardware and software required for the boiler manufacturer's gateway interface.

O. Alarm management

1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator

interruptions due to non-critical alarms, to minimize network traffic, and to prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

2. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

3. Prioritization:

   a. Set up all system analog points with high and low alarm limits. All digital system points shall be associated with a status feedback point and all exceptions shall be reported as alarms. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized and filtered to minimize nuisance reporting and to speed operator response to critical alarms.

   b. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

4. Critical and Non-Critical Alarm Routing:

   a. Critical alarms shall be defined as chiller, boiler, generator, critical space temperature or humidity, and kilowatt demand approaching threshold. Critical alarms shall be displayed at the workstation, printed at the alarm printer, and alpha paged to the on-duty maintenance person over the Owners alphanumeric paging system. Alpha pages shall provide sufficient information to identify the equipment and the point in alarm and the time and date of occurrence.

   b. All other alarms shall be considered non-critical and shall be displayed and acknowledged before being sent to the alarm log.

5. Report Routing:

   a. Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information.

   b. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

   c. Report routing to include pager, text, and email capabilities.

6. Alarm Messages:

   a. In addition to the point's descriptor and the time and date, the user shall be able to print, display, or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

b. Each stand-alone DDC panel shall be capable of storing a minimum library of 250 Alarm Messages. Each message may be assignable to any number of points in the panel.

7. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request is made, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

P. The system shall include the ability to define a status of occupied and unoccupied air flow rate and temperature requirements by space, type of space, or air system on a user defined night, day, day-of-week, weekday, and weekend categories. Additionally, the system shall allow local override of an unoccupied status in minimum 2-hour increments.

2.3 DDC EQUIPMENT

A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

d. Software applications, scheduling, and alarm processing.

e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.

b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.

d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

e. Remote communications.

f. Maintenance management.

g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

C. Communications: Meter outputs are analog or programmable pulse output and available to Modbus IP.I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.

6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.

7. Universal I/Os: Provide software selectable binary or analog outputs.

D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic. second response time for 50 percent load changes.

3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.

2. Maximum response time of 10 nanoseconds.

3. Minimum transverse-mode noise attenuation of 65 dB.

4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

## 2.4 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch-thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.

2. Acknowledge Switch: Horn is silent and indicating light is steady.

3. Second Alarm: Horn sounds and indicating light is steady.

4. Alarm Condition Cleared: System is reset and indicating light is extinguished.

5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.5 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 degrees F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.

2. Proportional band shall extend from 2 to 20 percent for 5 psig.

3. Authority shall be 20 to 200 percent.

4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.

5. Gauges: 1-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.6 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. Enclosures:

   a. For Conditioned Space: Dustproof rated for operation at 32 to 120 degrees F.

   b. For Outdoor and Non-conditioned Space: Waterproof rated for operation at -10 to 150 degrees F.

2.7 INPUT DEVICES

A. General Requirements: Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Current Sensing Relays

1. Manufacturer: Hawkeye model 908 or approved equal.

2. Current sensor shall induce power from the monitored load and shall have an adjustable operating range from 2.5 - 135 A.

3. Visual indicators (LED's) shall indicate output status and sensor power.

4. Adjustable trip set point to plus or minus 1 percent.

5. Current sensor output shall be normally open, solid state, 0.1A @ 30 VAC/DC.

C. Flow Measuring

1. General:

   a. A WAGES Monitoring Panel shall be provided and installed and shall be connected to the HCA IP network and reside on VLAN.

   b. Where devices have BACnet IP communications available and have been approved by HCA IT&S with an ISA on file then these meters shall use BACnet IP communications where meter readings are available as digital outputs, analog outputs or BACnet MS/TP communications with the meter output signal must be wired directly to a WAGES Monitoring Panel for logging and remote communications. It is preferred to use BACnet MS/TP in this scenario whenever possible.

   c. All devices shall be available to both Modbus TCP and BACnet IP based systems via the WAGES Panel.

1) Connect devices directly to the WAGES Panel via BACnet IP, BACnet MS/TP, MODBUS TCP, MODBUS RTU, hardwired digital input, or hardwired analog input.

2) Provide interpreters for each device as required from the native communications protocol of the device to the HCA protocol for seamless integration into the WAGES panel.

3) Additional devices not described in this specification but required by the documents shall be connected to the FMS and made available to the WAGES Panel via BACnet IP.

2. Air:

a. General:

1) Airflow measuring sensors shall be installed at fan inlet whenever possible and shall be capable of continuously measuring the air handling capacity (air volume) of the associated fan or fans.

b. Fan Inlet Piezometer Rings

1) Manufacturer: Paragon Controls Incorporated (PCI).

2) Materials:

a) 6063-T5 anodized aluminum.

b) For systems within 60 miles of the coast, use 316 stainless steel.

3) Accuracy: plus or minus 2 percent of full scale in an airstream greater than 600 feet per minute up to 350 degrees F and any relative humidity.

4) Fan inlet to be factory tapped for piezometers sensor ports.

c. Thermal Dispersion

1) Manufacturers:

a) Ebtron.

2) Description: Units shall be a measuring device in a glass or polymer bead that cools or changes resistance in a moving air stream. System shall be provided complete with differential pressure transducers, temperature compensation, square root extraction. Unit shall perform all internal calculations to output to the FMS the flow reading in cubic feet per minute (CFM).

3) Location: Provide straight duct before and after device according to the sensor manufacturer's recommendations. Provide access door in ductwork adjacent to sensors.

4) Accuracy: Sensor accuracy shall be plus or minus 2% of the airflow reading over the entire range of airflow measured.

d. Transmitter / Transducer

1) Each sensor shall be provided complete with transmitter.

2) Manufacturers:

a) Air Monitor Incorporated, Veltron model.

b) Paragon: MicroTrans model or FAATS-1000.

3) Full Scale Accuracy at 70 degrees F:

a) Accuracy: plus or minus 0.25 percent of full scale.

b) Terminal Point Non-linearity: plus or minus 0.2 percent.

c) Hysteresis: plus or minus 0.2 percent.

d) Non-repeatability: plus or minus 0.03 percent.

e) Temperature Effect: plus or minus 0.15 percent full scale per degree F.

4) The transmitter shall locally display the measured air velocity/volume in feet per minute and cubic feet per minute.

5) The transmitter shall accept local user input and shall display the flow area, calibration factor and the temperature used to determine the air density.

6) The transmitter-controller shall be capable of receiving flow signals (total and static pressure) from an airflow station or probe array and produce an output linear and scaled for air volume, velocity, differential pressure, etc. The internal P, I, three-mode controller shall be capable of controlling at a user selectable internal or external setpoint, and output a 0-5VDC, 0-10VDC, or 4-20mADC control signal.

7) The transmitter-controller shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output plus controller setpoint during normal operating mode. All transmitter configuration, parameter setting, zero and span calibration, plus display formatting and

scaling will be performed digitally in the on-board microprocessor via input pushbuttons.

8) The transmitter-controller will be available in multiple natural spans covering the range of 0.05" w.c. to 10.0" w.c. The transmitter-controller shall be furnished with a transducer automatic zeroing circuit, and maintain linear output signals on applications requiring 10 to 1 velocity or pressure turndown.

9) The transmitter-controller shall maintain its operating span electronically selected without having to perform recalibration involving an external pressure source. The transmitter-controller will provide the means of managing a system for automatic high pressure purge of the airflow station or probe array, with user selectable purge frequency and duration, while maintaining the last transmitter output during the purge cycle. Using a second transmitter as an input, the internal microprocessor can perform a summed flow, flow differential, low signal select, high signal select or percent deviation calculation, with the result being displayed and provided as an analog output signal.

3. Water:

a. General:

1) Sensors shall operate in line pressures up to 400 psi and liquid temperatures up to 220° F.

2) A certificate of calibration shall be provided with each flow meter.

3) Each flow meter shall be covered by the manufacturer's two-year warranty.

4) Provide meters with an integrally mounted graphical display that may be optionally remote mounted up to 1000 ft from the sensor.

b. Electromagnetic

1) Manufacturer:

a) Onicon, F3500 Series.

2) Accuracy:

a) Less than 2 feet per second: Plus, or minus 0.02 percent.

b) 2 to 30 feet per second: Plus, or minus 1 percent.

3) Provide complete sensor assembly with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.

4) Materials of construction for wetted metal components shall be 316 SS.

5) The flow meter shall average velocity readings from two sets of diametrically opposed electrodes.

6) Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1%.

7) Output signals shall be completely isolated and shall consist of the following:

a) (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable

b) (1) scalable dry contact output for totalization

c) (1) high resolution frequency output for use with peripheral devices such as an ONICON display module or BTU meter.

c. Turbine

1) Provide a metering insert containing the turbine rotor so that direct contact with the fluid pressure drives the turbine rotor rate proportional to the volumetric flow rate.

2) The rotor's rotation is magnetically coupled to a hermetically sealed indicator/reed switch contacts.

3) Wetted metal components shall be:

a) NPS 0.75 to 1.5: Nickel-plated brass.

b) NPS 2 to 10: Epoxy coated cast iron.

4) Accuracy: plus or minus 1 percent of the calibrated velocity and a turn down of:

a) NPS 0.75 to 1.5: 32:1.

b) NPS 2 to 10: 55:1.

5) Analog output for connection to W.A.G.E.S. panel:

a) 4-20 mA

b) 0-10V

c) 0-5V

d) Isolated Dry Contact Pulse

6) Environment: Fully wetted in a fluid from 25 degrees F to 300 degrees F.

d. Transmitter / Transducer

1) Each sensor shall be provided complete with transmitter.

2) Water meter: The analog transmitter shall be Data Industrial Model 310-00, or equivalent.

3) The analog flow transmitter shall be a loop powered device capable of transmitting a linear 4 - 20 mA signal proportional to frequency. The unit shall be microprocessor controlled with no switches or potentiometers to set.

4) The transmitter shall meet ISA Class L, H and U non-isolated requirements. All circuitry shall be encapsulated in a low profile epoxy body to meet MIL spec M.1- 146058C type AR, for humidity, moisture and fungus resistance. Operating range shall be 35 degrees F to 150 degrees F.

5) All programming, including flow sensor selection, pipe size, flow range setting, response time and filtering shall be set digitally via a computer using Windows-based software with programming kit (disk and cable). The transmitter shall be easily programmed in the field using a standard computer.

6) The transmitter shall have a ground lug to maximize EMI protection when necessary. The transmitter shall be mounted directly near the insertion flow sensor on a DIN Rail, as a panel mount or in a weather proof or NEMA 4X enclosure.

4. Steam: Vortex Mass Flow Meter

a. Construction

1) Body: 300 series stainless steel.

2) Enclosure: Aluminum with NEMA-4 rating.

3) Flanges: ANSI class 150 or 300 as required by connected system.

4) Display: LCD to indicate mass flow rate and mass flow total and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.

b. Sensor: 1000-ohm platinum RTD, integral to the meter with real-time calculation of mass flow corrected for density.

c. Accuracy: plus or minus 1.5 percent or actual reading over full range, including errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation.

d. Environment: maximum operating temperature of 460 degrees F.

e. Provide a flow straightener, if required to meet the manufacturer's minimum upstream straight pipe run requirement.

f. Provide lateral and horizontal supports as required to minimize vibration at the meter location.

g. Calibration:

1) Calibrate each flow meter individually at five points from 0-250 feet per second against the manufacturer's flow standards.

2) The manufacturer shall provide a certificate of calibration for each meter.

h. Programming: The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

i. Output:

1) 4-20 mA signal, powered by the system loop, calibrated in direct mass flow rate units for connection to the Energy Monitoring System.

2) Integral pulse output for steam mass flow totalizing shall be provided.

3) All outputs shall be linear with mass flow rate.

5. Gas: Thermal Mass Flow Meter

a. Manufacturer: Onicon F-5500 connected to Onicon D-100 communication relay.

b. General:

1) Insertion type with hybrid analog/digital sensing circuitry with no moving parts for continuous measuring and indicating the accurate measurement of clean, dry natural gas at constant and variable flow rates.

2) The sensor design measures mass flow directly and does not require additional pressure or temperature compensation to deliver accurate flow data.

c. Construction

1) Sensor: 316L for all wetted components and covering platinum windings of head.

2) Enclosure: Aluminum with NEMA-4 rating.

3) Display: LCD to indicate mass flow rate and mass flow total and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions, valid calibration, and the proper operation of the meter.

d. Accuracy:

1) 100 – 500 standard feet per minute: plus or minus 2.0 percent of actual reading.

2) 501 – 7000 standard feet per minute: plus or minus 1.0 percent of actual reading.

e. Environment:

1) Temperature: -40 degrees F to 200 degrees F.

2) Pressure: 500 psi.

f. Provide lateral and horizontal supports as required to minimize vibration at the meter location.

g. Calibration: NIST traceable calibration for meter with certificate.

h. Programming: The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

i. Output:

1) 4-20 mA signal with scalable pulse.

2) Active 24 VDC pulse, 500 ms duration.

3) All outputs shall be linear with mass flow rate.

6. BTUH Meter

a. BTUH Meter shall be Onicon System 10.

b. Insertion type, with associated flow meter.

c. Calibration: NIST traceable calibration for meter and solid state temperature sensors.

d. Temperature sensors: Solid state with differential temperature accuracy of plus or minus 0.15 degree F over calibrated range.

e. Communication: BACnet IP.

f. Provide meters with an integrally mounted graphical display that may be optionally remote mounted up to 1000 ft from the sensor.

D. Humidity

1. Acceptable Manufacturers: Johnson Controls.

2. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.

3. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

4. The humidity transmitter shall meet overall accuracy, including lead loss and Analog to Digital conversion.

5. Outside air relative humidity sensors shall include a rain proof, perforated cover. Provide transmitter with a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.

6. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

7. Indoor service

a. Accuracy: plus or minus 3 percent in an airstream between plus 59 deg to 95 degrees F in the range of 5 to 95 percent RH.

b. Repeatability: plus or minus 0.5 percent.

c. Operating Environment:

1) Pressure: Ambient, plus or minus 10 inches water column.

d. Temperature: plus 32 degrees F to 122 degrees F, non-condensing.

e. Stability: plus or minus 1 percent RH at 50 percent RH in 5 years.

8. Outdoor service

a. Accuracy: plus or minus 2 percent in an airstream between 0 and plus 180 degrees F.

b. Repeatability: plus or minus 0.5 percent.

c. Operating Environment:

1) Pressure: Ambient, plus or minus 20 inches water column.

2) Temperature:

a) Electronics: minus 20 degrees F to plus 160 degrees F.

b) Probe: minus 20 degrees F to plus 180 degrees F.

d. Stability: plus or minus 1 percent RH at 50 percent RH in 5 years.

e. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

E. Power Monitoring

1. Current Measurement (Amps):

a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.

1) Operating frequency – 50 - 400 Hz.

2) Insulation – 0.6 Kv class 10Kv BIL.

3) UL recognized.

4) Five amp secondary.

5) Select current ration as appropriate for application.

c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

1) 6X input over amp rating for AC inrushes of up to 120 amps.

2) Manufactured to UL 1244.

3) Accuracy: +.5%, Ripple +1%.

4) Minimum load resistance 30kOhm.

5) Input 0-20 Amps.

6) Output 4-20 mA.

7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

2. Electric Power Meter

a. Manufacturer: Schneider PowerLogic

1) Switchboards: #PM750

2) Socket mounts: E5600

b. Accuracy: ANSI C12.20 Class 0.5S.

c. Power monitor to continuously meter and record 15 minute intervals. All readings shall be available per phase and total. Monitor the following:

1) Energy readings for 1, 2, or 3 phase load.

2) Power demand

3) Instantaneous power

4) Max power

5) Peak demand

6) Energy power factor

7) Amps

8) Volts

F. Pressure

1. Air and Water Pressure Transmitter Requirements:

a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

b. Differential pressure transducers shall be piped to permit equalizing pressure prior to disconnecting.

c. Differential pressure sensors used to control equipment such as fans and pumps, shall be connected directly to the same controller that controls the equipment to insure the continued proper operation of the controlled equipment without dependence on the control network.

2. Differential Pressure Transducer for Terminal Boxes

a. Manufacturer: Same as controls manufacturer.

b. Pressure range: 0 to plus 1.5 inches water column.

c. Overpressure limit: 1 PSI.

d. Accuracy:

1) Linearity: plus or minus 0.008 inches water column in an airstream up to 1 inch water column.

2) Repeatability: plus or minus 0.00075" water column, maximum.

3) Stability: plus or minus 0.01 inches water column for zero and span, maximum.

4) Temperature Effects: plus or minus 0.0004 inches water column for zero and span, maximum.

5) Position Effects:

a) Zero: plus or minus 0.1 VDC, maximum.

b) Span: plus or minus 0.05 VDC, maximum.

3. Duct Mounted

a. Manufacturers:

1) Air Monitor Corporation.

2) Paragon Controls (Model PE-5000).

3) Setra.

b. Materials: 6063-T5 Anodized Aluminum.

c. Accuracy: less than 2% of true reading in an airstream greater than 600 feet per minute and up to 350 degrees F at any relative humidity.

4. Room Differential Pressure Sensors

a. Manufacturers:

1) Setra.

2) Siemens.

3) TSI PresSura.

b. Accuracy: plus or minus 10 percent of reading at 0.0000 inches water column.

c. Range: plus or minus 0.2000 inches water column.

d. Resolution: 5 percent of reading.

e. Communications: RS-485 for interface with FMS.

f. Display

1) Digital readout with at least 2 lines of lettering.

2) Accept pressure measurement from at least two spaces.

3) Relay alarms and readings to a remote panel.

4) Local Display Update: 0.5 seconds.

g. Alarm contacts to close while in alarm.

h. Analog outpus: 0-10 VDC or 4-20 mA.

G. Smoke Detectors:

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be as specified in Division 28 - Fire Alarm System.

H. Status and Safety

1. General Requirements:

a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the FMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches:

a. The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

3. Air Filter Status Sensors:

   a. Differential pressure sensors shall be installed across all filters and connected to the BAS

   b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

   c. Provide appropriate scale range and differential adjustment for intended service.

4. Air Flow Switches:

   a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

5. Air Pressure Safety Switches:

   a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

   b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

6. Water Flow Switches: Equal to the Johnson Controls P74.

7. Low Temperature Limit Switches: Equal to Johnson Controls A70.

   a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

   b. The sensing element shall be one foot long for each square foot of coil area and be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

   c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

I. Temperature

1. General Requirements:

   a. The temperature sensor shall be of the resistance type, and shall be a two-wire 1000-ohm platinum RTD.

      1) Accuracy: plus or minus 0.3 degrees F or better, including errors associated with the sensor, lead wire, and A to D conversion.

2) Stability: less than 0.1 degrees F change in 5 years.

3) Environment: minus 20 degrees F of anticipated minimum and plus 20 degrees F of anticipated maximum service.

2. Air Temperature Switches: Vapor-filled sensing element with adjustable set point and minimum of 5 degrees F temperature differential.

3. Averaging Sensors: Capillary tube type with accuracy of plus or minus 0.3 degrees F.

4. Duct Mount Sensors:

a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.

b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

5. Outside Air Sensors:

a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.

b. Sensors shall be shielded by a perforated plate that surrounds the sensor element.

c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

6. Room Temperature Sensors

a. Room sensors shall be constructed for either surface or wallbox mounting.

b. Room sensors shall have the following options:

1) Setpoint reset slide switch providing a +5 degree (adjustable) range.

2) Individual heating/cooling setpoint slide switches.

7. Room Temperature Sensors with Integral Display:

a. Room sensors shall be constructed for either surface or wallbox mounting.

b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

1) Display room temperature.

2) Display and adjust room comfort setpoint.

3) Display and adjust fan operation status.

4) Timed override request push button with LED status for activation of after-hours operation.

5) Display controller mode.

6) Password selectable adjustment of setpoint and override modes.

8. Thermowells:

a. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.

b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.

c. Thermowells and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.

d. Thermowells shall be constructed of 316 stainless steel.

J. EPO Switches

1. General Description: All products listed shall meet the following requirements:

a. Operators shall be heavy duty type and comply with UL Type 13/NEMA Type 13 and UL Type 6/NEMA Type 6.

b. Contact blocks shall be rated 10 amperes continuous.

2. EPO Design:

a. Mushroom type: Flush mounted, two position, maintained push - maintained pull mushroom head type push button operator with 2.25 inch diameter mushroom top, red, with one normally open and one normally closed (1NO - 1NC) contact. Provide with aluminum extended mushroom guard.

2.8 OUTPUT DEVICES

A. Actuators:

1. General Requirements:

a. Damper and valve actuators shall be electronic, as specified in the System Description section.

2. Electronic Damper Actuators:

a. Electronic damper actuators shall be direct shaft mount, as manufactured by Johnson Controls, Siemens, or Belimo.

b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, or a gear release to allow manual positioning.

c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, proportional control.

d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

3. Electronic Valve Actuators:

a. Electronic valve actuators shall be manufactured by the valve manufacturer or Belimo Air Controls. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

c. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, proportional control.

d. For ball valves, the actuator's controller output shall be capable of being spanned to compensate for the two stem travel ranges, 0 – 20% open and 85 – 100% open, where the ball valve exhibits no change in flow with stem travel.

e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

B. Control Dampers:

1. Furnish all automatic dampers that are not furnished with air handling units. Coordinate exact damper requirements with the air handling unit manufacturer. All automatic dampers shall be sized for the application or as specifically indicated on the Drawings.

2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is sufficient its close-off pressure drop to shift the characteristic curve to near linear.

3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

4. All dampers used for smoke control applications shall be UL 555 listed.

5. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 48". Damper blades shall be 16-gauge minimum and shall not exceed six (6) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. Additional stiffening or bracing shall be provided for any section exceeding 48" in height. All damper bearings shall be made of stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomeric seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak more than 8.5 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

6. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers: Johnson Controls D-1300, Ruskin CD50, and Vent Products 5650.

7. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.

8. Acceptable manufacturers: Johnson Controls D-1100, Ruskin CD36, and Vent Products 5800.

9. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays:

1. Control Pilot Relays:

a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.

b. Mounting bases shall be snap-mount.

c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

d. Contacts shall be rated for 10 amps at 120VAC.

e. Relays shall have an integral indicator light and check button.

D. Control Valves:

1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Section.

2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no more than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no more than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no more than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

3. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel.

4. Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units.

5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

6. Control valves for ball valves shall not use pulse of tri-mode controllers or actuators. Controllers installed shall be capable of being spanned for the two stem travel ranges of 0-20% open and 85-100% open.

E. Electronic Signal Isolation Transducers:

1. A signal isolation transducer shall be provided whenever an analog output signal from the Facility Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.

2. The signal isolation transducer shall provide ground plane isolation between systems.

3. Signals shall provide optical isolation between systems.

F. Motor starters: an integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.

1. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.

2. A Status LED shall illuminate whenever the output is ON.

3. An Override LED shall illuminate whenever the HAND/OFF/AUTO switch is in either the HAND or OFF position.

4. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

G. Variable frequency motor controllers: an integral HAND/AUTO pushbutton shall override the controlled device pilot relay.

1. A status input to the Facility Management System shall indicate whenever the controller is in the hand or bypass position.

2. A Status LED shall illuminate whenever the output is ON.

3. An Override LED shall illuminate whenever the HAND/AUTO push button is in either the HAND or OFF position.

4. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

2.9 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

2.10 WAGES Panel

A. Manufacturer: Schneider Electric, Model #9761HCSXWAUTSVRENC

B. General: 24-inch x 24-inch x 10-inch NEMA Type 1 enclosed with the capability of accepting preprogrammed input channels:

1. (16) meter inputs directly wired to the WAGES Panel

2. (8) meters via BACnet IP or BACnet MSTP communications.

3. The panel shall be factory configured to automatically calculate flow and consumption once meter scaling and serial addressing are configured.

4. The WAGES Panel shall allow electrical and mechanical meter data be accessible via BACnet IP for auto discovery by the facility BAS.

5. The meter data made available via this communication shall include all physical points of measurement and calculated values of summation.

6. The WAGES panel shall also make all Electrical and Mechanical metering data including any FMS points mapped into the WAGES panel available via MODBUS TCP for integration to the Schneider Electric Power Monitoring Expert and Enterprise Energy Manager software.

C. Features:

1. StruxureWare Automation Server with support for BacNet MSTP, BACnet IP, Modbus RTU, Modbus TCP and LonWorks.

2. UI-16 Universal Digital Input Module.

3. PS-24 power supply & dedicated 96VA control power transformer.

4. Additional 120-24VAC, 96VA control power transformer for powering field devices.

5. "HCA WAGES Template" program factory loaded with site specific IP address.

6. Include drivers to allow for BACnet IP communications to the WAGES panel to allow the FMS to have access to specific electrical and mechanical metering data via the WAGES panel with bi-directional communications so the WAGES panel can also have access via BACnet IP to selected BAS data points.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Sensors and transmitters shall be provided, installed, and connected into the FMS as outlined in documents, including the input/output summary and sequence of operations.

B. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

1. Connect and configure equipment and software to achieve sequence of operation

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and architectural room details before installation. Install devices 48 inches above the floor.

D. Install manual reset switches, such as high and low static resets, no higher than 6'-0" above nearest adjacent finished floor.

E. Install averaging elements in ducts, plenums, and coil faces in crossing or zigzag pattern.

1. Provide one linear foot of sensor per square foot of coil in a pattern that will create an even distribution of sensor over the entire cross sectional area of duct or air handling unit.

2. Provide multiple sensor elements where maximum length of one element is exceeded.

F. Install freezestats to provide one linear foot of sensor per square foot of coil.

G. Install temperature sensor on the leaving side of all cooling and heating coils in AHUs.

H. Install outdoor air temperature sensors on a north facing wall and away from direct sunlight as well as 20 feet (minimum) from exhaust or relief air fans.

I. Install outdoor air humidity sensors on a north facing wall and away from direct sunlight as well as 20 feet (minimum) from exhaust or relief air fans. Do not install

within 20 feet of cooling tower discharge, steam vents, or downstream of similar services in the direction of typical wind patterns.

J. Install guards on thermostats in the following locations:

1. Entrances.

2. Public areas.

3. Where indicated.

K. Install BTU meters for the following systems:

1. Chilled Water.

2. Heating Water.

L. Flow Station Locations:

1. General: Maintain upstream and downstream distances for straight flow and offsets from other fittings and/or obstructions as required by the manufacturer.

2. Air side

a. Provide piezometer ring type at fan inlet for all fans located in AHUs and as indicated on drawings.

b. Fans external to AHU to be thermal dispersion type installed at the fan inlet.

c. Duct mounted flow stations shall be thermal dispersion type.

d. Transmitter/Transducer:

1) Single Fans: MicroTrans or Veltron.

2) Fan Arrays with 4 or more elements: FAATS-1000.

3. Water side

a. General:

1) Adequate straight pipe shall be installed before (10 pipe diameters) and after (5 pipe diameters) device, or as required by the manufacturer's recommendations.

2) Provide meters for each main service as well as significant branches to adjacent buildings.

3) Provide meters for services dedicated to each tenant.

b. Electromagnetic

1) chilled water

2) closed condenser water

3) heating water

c. Turbine

1) boiler feed water

2) pumped condensate

3) cooling tower make-up

4) cooling tower blow down

5) deaerator make-up

6) domestic cold water

7) irrigation water

4. Vortex

a. Each steam boiler.

b. Steam supply mains.

5. Thermal Mass

a. Main gas entry.

b. Domestic water heating system.

c. Hot water system.

d. Steam system.

e. Each boiler feed.

M. Install humidity sensors and echo local alarms to the FMS, for the following occupied spaces:

1. Operating Rooms.

N. Install pressure monitors across walls dividing spaces with monitored pressure requirements and echo local alarms to the FMS, including the following spaces:

1. Operating Rooms

O. Install differential pressure switches across all filters, including those in air handling equipment and air devices, and connect switches to the FMS for monitor, trend, and alarm.

P. Install temperature sensors applied as follows:

1. Duct Mounted

a. Outside Air:

1) Type: Thermal dispersion.

2) Accuracy: plus or minus 0.5 degrees F of reading.

b. Return and Supply Air:

1) Type:

a) Thermal dispersion.

b) RTD.

2) Accuracy: plus or minus 0.3 degrees F of reading.

2. Equipment Mounted.

a. AHU Outside Air Intake

1) Type: Thermal dispersion

2) Accuracy: plus or minus 0.5 degrees F of reading.

b. Coil Averaging Temperature

1) Type: Capillary tube.

2) Accuracy: Plus, or minus 0.3 degrees F of reading.

c. Coil Low Temperature Control

1) Type: Vapor-filled tube.

2) Accuracy: plus or minus 0.3 degrees F of reading.

d. Fan Temperature

1) Type: Thermal dispersion.

2) Accuracy: plus or minus 0.3 degrees F of reading.

3. Piped Services

a. Chilled Water:

1) Type: RTD.

2) Accuracy: plus or minus 0.5 degrees F of reading.

b. Condenser Water, Heating Water, Steam, and Steam Condensate:

1) Type: RTD.

2) Accuracy: plus or minus 0.75 degrees F of reading.

4. Wall Mounted

a. Operating Rooms

1) Room temperature sensor with integrated display.

2) Provide display only of room relative humidity on same display.

b. Patient Areas

1) Surface mounted campus standard room temperature sensor with integrated display.

c. Public Areas

1) Stainless steel plate with tamper-proof fasteners and RTD in contact with inside face of plate.

Q. Coordinate EPO switch location and type with Division 26. Install EPOs as follows:

1. Mushroom:

a. Each AHU

R. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

S. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

T. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

U. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

V. Install steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam and Condensate Heating Piping."

W. Install WAGES RTU panels in each equipment room that contains analog or pulse metering. Provide enough WAGES RTUs to capture all associated meters. Minimum performance and storage capabilities may be exceeded to reduce the number of physical panels while maintaining the same level of system performance of monitor, trending, and reporting.

X. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."

Y. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

Z. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

AA. Unit Heaters: Unit heaters shall each be provided with a low voltage electric wall-mounted room thermostat, which shall cause the heater to be cycled "on" or "off" as required to satisfy the thermostat setting. Control circuit voltage shall not exceed 120 volts to ground. In the off position, water shall be circulated through the unit.

BB. Cooling Tower Basin Heating: When the outside air temperature reaches 35 degrees F. (adj.), the cooling tower basin heating system shall be activated to maintain a 40 degree F. basin water temperature.

CC. Provide total terminal box airflow for each AHU to be shown as separate point in the FMS graphics in addition to the AHU supply airflow, in CFM, set point.

3.3 EQUIPMENT STATUS MONITORS

A. Current sensing relays are to be installed across motors and must be sensitive enough to detect and alarm when driven equipment, such as a fan motor is operating without a belt or a pump motor is operating without flow.

B. Where a current sensing relay is not as described above, provide a differential pressure transducers/switches to monitor equipment status.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.

2. Install exposed cable in raceway.

3. Install concealed cable bundled, labeled for service, and well supported to prevent contact with other systems.

4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.

5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.

7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches or hand/auto push buttons to override automatic interlock controls when switch or pushbutton is in hand position.

3.5 WAGES Panel

A. Install WAGES panel in mechanical room. WAGES sub-panels may be used to collect groups of remote meters to relay back to the primary WAGES panel or communicate directly back to the VLAN.

B. Connect the following metering devices to the WAGES panel:

1. Electrical: Meter the following systems and communicate with the Modbus protocol.

a. Normal Power Service Mains

b. Emergency Generator Mains

c. Emergency Generators

d. Automatic Transfer Switches

e. Chiller Power

f. Sub-meters to separate business entities.

2. Mechanical

a. VFDs

b. BTU Meters:

1) Chilled water.

2) Heating water.

c. Flow Meters:

1) Chilled water

2) Closed condenser water

3) Heating water

4) Boiler feed water

5) Pumped condensate

6) Cooling tower make-up

7) Cooling tower blow down

8) Deaerator make-up

d. Gas Meters:

1) Each steam boiler.

2) Steam supply mains.

3) Main gas entry.

4) Domestic water heating system.

5) Hot water system.

6) Steam system.

7) Each boiler feed.

3. Plumbing

a. Domestic cold water

b. Irrigation water

4. Sub-meters for additional buildings or services.

5. Additional points as indicated in the documents.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check instrument tubing for proper fittings, slope, material, and support.

5. Check installation of air supply for each instrument.

6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

8. Check temperature instruments and material and length of sensing elements.

9. Check control valves. Verify that they are in correct direction.

10. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.

    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.

    c. Verify that spare I/O capacity has been provided.

    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.7 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.

    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.

    c. Check digital inputs using jumper wire, including:

        1) Status indicators for fans shall be tested to indicate an alarm upon belt loss or dead-head pump condition. Adjust current sensing relays appropriately.

        2) Status indicators for preheat circulating pumps shall be tested to indicate an alarm upon dead-head condition. Adjust current sensing relay appropriately.

    d. Check digital outputs using ohmmeter to test for contact making or breaking.

    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.

   b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.

   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.

   b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.

11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide for visits to Project during other than normal occupancy hours for this purpose.

D. Furnish the Contractor with the appropriate DDC system software available to assist in the test and balance process.

E. Provide a technician for 8 hours to assist/train the TAB technician in the coordination/ interface of the BAS with the TAB activities.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

**END OF SECTION**

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# SECTION 23 11 23

# FACILITY NATURAL-GAS PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results" for escutcheons and grout.
2. Division 23 Section "Hangers and Supports" for hangers.

1.2 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.
3. Minimum Operating Pressure of Service Meter: 5 psig.

B. Natural-Gas System Pressure within Buildings: More than 2 psig but not more than 5 psig.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.3 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.

5. Escutcheons.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: 1/8 inch per foot.

1.4 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. Welding certificates.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motorized gas valves, pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein. All products to be purchased from Ferguson Enterprises.

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

C. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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.

1.7 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 Construction Manager and Owner no fewer than ten 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.

1.8 COORDINATION

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

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

## PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

a. Material Group: 1.1.

b. End Connections: Threaded or butt welding to match pipe.

c. Lapped Face: Not permitted underground.

d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.

e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:

a. Available Manufacturers:

1) Dresser Piping Specialties; Division of Dresser, Inc.

2) Smith-Blair, Inc.

b. Steel flanges and tube with epoxy finish.

c. Buna-nitrile seals.

d. Steel bolts, washers, and nuts.

e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

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

B. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.

2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.

b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.

c. Aboveground Portion: PE transition fitting.

d. Outlet shall be threaded or flanged or suitable for welded connection.

e. Tracer wire connection.

f. Ultraviolet shield.

g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.

b. Outlet shall be threaded or flanged or suitable for welded connection.

c. Bridging sleeve over mechanical coupling.

d. Factory-connected anode.

e. Tracer wire connection.

f. Ultraviolet shield.

g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

5. Plastic Mechanical Couplings, NPS 1-1/2 and Smaller: Capable of joining PE pipe to PE pipe.

a. Available Manufacturers:

1) Lyall, R. W. & Company, Inc.

2) Mueller Co.; Gas Products Div.

3) Perfection Corporation; a subsidiary of American Meter Company.

b. PE body with molded-in, stainless-steel support ring.

c. Buna-nitrile seals.

d. Acetal collets.

e. Electro-zinc-plated steel stiffener.

6. Plastic Mechanical Couplings, NPS 2 and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Available Manufacturers:

1) Lyall, R. W. & Company, Inc.

2) Mueller Co.; Gas Products Div.

3) Perfection Corporation; a subsidiary of American Meter Company.

b. Fiber-reinforced plastic body.

c. PE body tube.

d. Buna-nitrile seals.

e. Acetal collets.

f. Stainless-steel bolts, nuts, and washers.

7. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Available Manufacturers:

1) Dresser Piping Specialties; Division of Dresser, Inc.

2) Smith-Blair, Inc.

b. Steel flanges and tube with epoxy finish.

c. Buna-nitrile seals.

d. Steel bolts, washers, and nuts.

e. Factory-installed anode for steel-body couplings installed 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: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.

3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.

2. End Connections: Grooved ends.

3. Strainer Screen: 60-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.

4. CWP Rating: 750 psig.

D. 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. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 100 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 "Aboveground Manual Gas Shutoff Valve Schedule" Article.

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.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 100 psig.

2. Flanged Ends: Comply with ASME B16.5 for steel flanges.

3. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.

4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Available Manufacturers:

a. BrassCraft Manufacturing Company; a Masco company.

b. Conbraco Industries, Inc.; Apollo Div.

c. Lyall, R. W. & Company, Inc.

d. McDonald, A. Y. Mfg. Co.

e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.

3. Ball: Chrome-plated brass.

4. Stem: Bronze; blowout proof.

5. Seats: Reinforced TFE; blowout proof.

6. Packing: Separate packnut with adjustable-stem packing threaded ends.

7. Ends: Threaded, flared, or socket as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.

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.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Available Manufacturers:

    a. BrassCraft Manufacturing Company; a Masco company.

    b. Conbraco Industries, Inc.; Apollo Div.

    c. Lyall, R. W. & Company, Inc.

    d. McDonald, A. Y. Mfg. Co.

    e. Perfection Corporation; a subsidiary of American Meter 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 "Aboveground Manual Gas Shutoff Valve Schedule" Article.

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. Available Manufacturers:

    a. Lee Brass Company.

    b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.

3. Plug: Bronze.

4. Ends: Threaded, socket, or flanged as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.

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.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Available Manufacturers:

a. McDonald, A. Y. Mfg. Co.

b. Mueller Co.; Gas Products Div.

c. Xomox Corporation; a Crane company.

2. Body: Cast iron, complying with ASTM A 126, Class B.

3. Plug: Bronze or nickel-plated cast iron.

4. Seat: Coated with thermoplastic.

5. Stem Seal: Compatible with natural gas.

6. Ends: Threaded or flanged as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.

7. Operator: Square head or lug type with tamperproof feature where indicated.

8. Pressure Class: 125 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.

G. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Available Manufacturers:

a. Flowserve.

b. Homestead Valve; a division of Olson Technologies, Inc.

c. McDonald, A. Y. Mfg. Co.

d. Milliken Valve Company.

e. Mueller Co.; Gas Products Div.

f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.

2. Body: Cast iron, complying with ASTM A 126, Class B.

3. Plug: Bronze or nickel-plated cast iron.

4. Seat: Coated with thermoplastic.

5. Stem Seal: Compatible with natural gas.

6. Ends: Threaded or flanged as indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Article.

7. Operator: Square head or lug type with tamperproof feature where indicated.

8. Pressure Class: 125 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.

H. PE Ball Valves: Comply with ASME B16.40.

1. Available Manufacturers:

a. Kerotest Manufacturing Corp.

b. Lyall, R. W. & Company, Inc.

c. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: PE.

3. Ball: PE.

4. Stem: Acetal.

5. Seats and Seals: Nitrile.

6. Ends: Plain or fusible to match piping.

7. CWP Rating: 80 psig.

8. Operating Temperature: Minus 20 to plus 140 deg F.

9. Operator: Nut or flat head for key operation.

10. Include plastic valve extension.

11. Include tamperproof locking feature for valves where indicated on Drawings.

I. Valve Boxes:

1. Cast-iron, two-section box.

2. Top section with cover with "GAS" lettering.

3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.

4. Adjustable cast-iron extensions of length required for depth of bury.

5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Available Manufacturers:

a. ASCO Power Technologies, LP; Division of Emerson.

b. Dungs, Karl, Inc.

c. Eaton Corporation; Controls Div.

d. Eclipse Combustion, Inc.

e. Honeywell International Inc.

f. Johnson Controls.

2. Body: Brass or aluminum.

3. Seats and Disc: Nitrile rubber.

4. Springs and Valve Trim: Stainless steel.

5. Normally closed.

6. Visual position indicator.

7. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Available Manufacturers:

a. ASCO Power Technologies, LP; Division of Emerson.

b. Dungs, Karl, Inc.

c. Eclipse Combustion, Inc.

d. Goyen Valve Corp.; Tyco Environmental Systems.

e. Magnatrol Valve Corporation.

f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.

g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

2. Pilot operated.

3. Body: Brass or aluminum.

4. Seats and Disc: Nitrile rubber.

5. Springs and Valve Trim: Stainless steel.

6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.

7. NEMA ICS 6, Type 4, coil enclosure.

8. Normally closed.

9. Visual position indicator.

2.6 EARTHQUAKE VALVES

A. Earthquake Valves: Comply with ASCE 25.

1. Available Manufacturers:

a. Vanguard Valves, Inc.

b. Pacific Seismic Products, Inc.

2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.

3. Maximum Operating Pressure: 5 psig**.**

4. Wall mounting bracket with bubble level indicator.

5. Valve position, open or closed, indicator.

6. Composition valve seat with clapper held by spring or magnet locking mechanism.

7. End Connections: Threaded for valves NPS 2 and smaller; flanged for valves NPS 2-1/2 and larger.

2.7 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. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Available Manufacturers:

a. Actaris.

b. American Meter Company.

c. Fisher Control Valves and Regulators; Division of Emerson Process Management.

d. Invensys.

e. Richards Industries; Jordan Valve Div.

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.

11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

12. Maximum Inlet Pressure: 100 psig.

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

1. Available Manufacturers:

a. Actaris.

b. American Meter Company.

c. Eclipse Combustion, Inc.

d. Fisher Control Valves and Regulators; Division of Emerson Process Management.

e. Invensys.

f. Maxitrol Company.

g. Richards Industries; Jordan Valve Div.

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.

11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

12. Maximum Inlet Pressure: 5 psig.

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

1. Available Manufacturers:

a. Canadian Meter Company Inc.

b. Eaton Corporation; Controls Div.

c. Harper Wyman Co.

d. Maxitrol Company.

e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.

3. Springs: Zinc-plated steel; interchangeable.

4. Diaphragm Plate: Zinc-plated steel.

5. Seat Disc: Nitrile rubber.

6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.

8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

9. Maximum Inlet Pressure: 5 psig.

2.8 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Available Manufacturers:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Hart Industries International, Inc.

d. McDonald, A. Y. Mfg. Co.

e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

f. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 100 psig.

3. Combination fitting of copper alloy and ferrous materials.

4. Insulating materials suitable for natural gas.

5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Available Manufacturers:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.

d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 100 psig.

3. Combination fitting of copper alloy and ferrous materials.

4. Insulating materials suitable for natural gas.

5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Available Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 100 psig.

3. Companion-flange assembly for field assembly.

4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.

5. Insulating materials suitable for natural gas.

6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.9 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.10 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

## 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. For renovations and additions close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 and all applicable codes to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and all applicable code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and all applicable codes for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

2. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

F. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

G. Install pressure gage upstream and downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and all applicable codes for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons, after Architect's final approval of finish, for penetrations of walls, ceilings, and floors according to the following:

1. New piping penetrations shall be one-piece escutcheons.

2. Existing piping penetrations shall be two-piece escutcheons.

3. All sleeved penetrations shall be deep-drawn to allow flush installation between escutcheon and finished surface.

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

M. Verify final equipment locations for roughing-in.

N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

Q. Conceal pipe installations in pipe spaces, utility spaces, above ceilings, in floor channels unless indicated to be exposed to view.

R. 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 Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

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.

S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

T. Connect branch piping from top or side of horizontal piping.

U. 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.

V. Do not use natural-gas piping as grounding electrode.

W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

X. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23Section "Meters and Gages for HVAC Piping."

3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

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

C. Install earthquake valves aboveground outside buildings according to listing.

D. Install anode for metallic valves in underground PE piping.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.

2. Cut threads full and clean using sharp dies.

3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.

4. Apply appropriate tape or thread compound to external pipe threads unless 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. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. 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.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 CONNECTIONS

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

B. 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.

C. 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 Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.9 PAINTING

A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and all applicable codes and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

3.12 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:

1. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.

2. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas 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.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.13 INDOOR PIPING SCHEDULE

A. Aboveground, branch piping NPS 2and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping NPS 2-1/2 and larger shall be one of the following:

1. Steel pipe with wrought-steel fittings and welded joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

D. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.14 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. One-piece, bronze ball valve with bronze trim.

2. Two-piece, full-port, bronze ball valves with bronze trim.

3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.

2. Bronze plug valve.

3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.

2. Two-piece, full-port, bronze ball valves with bronze trim.

3. 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.

3. Cast-iron, nonlubricated or lubricated plug valve.

E. Valves in branch piping for single appliance shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.

2. Two-piece, full-port, bronze ball valves with bronze trim.

3. Bronze plug valve.

**END OF SECTION**

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# SECTION 23 21 13

# HYDRONIC PIPING

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, and joining methods for the following:

1. Makeup-water piping.

2. Condensate-drain piping.

B. Related Sections include the following:

1. Division 23 Section "General-Duty Valves for HVAC Piping" for valves and accessories for piping.

2. Division 23 Section "HVAC Insulation" for pipe saddles at pipe hangers.

3. Division 23 Section "Steam and Condensate Heating Piping".

4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic and wind restraint requirements.

5. Division 23 Section "Common work results for HVAC" for Pressure-Seal installer requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding 150 psig at the corresponding temperature as the minimum working pressure and temperature, unless otherwise indicated:

1. Hot-Water Heating Piping: 200 deg F.

2. Condenser-Water Piping: 200 deg F.

3. Makeup-Water Piping: 200 deg F.

4. Condensate-Drain Piping: 200 deg F.

5. Blowdown-Drain Piping: 200 deg F.

6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

7. Pre-insulated Piping Systems: Same as the piping system to which it is attached.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pressure-seal fittings where Capital Deployment Construction Management has pre-approved in writing.

2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

3. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Qualification Data: For Installer.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

E. All underground distribution systems shall be designed in strict conformance to the latest edition of ANSI B31.1 or local requirements, whichever is more stringent, and sealed by a Registered Professional Engineer in good standing with state and local authorities. The system shall be designed to compensate for stresses and movement of the service pipe.

1.5 QUALITY ASSURANCE

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein. All products to be purchased from Ferguson Enterprises.

B. All piping shall be American manufactured, unless otherwise indicated.

C. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

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

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

E. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.6 EXTRA MATERIALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

## PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

E. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

C. 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.

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

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:

1. Manufacturers:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Hart Industries International, Inc.

d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:

1. Manufacturers:

a. Capitol Manufacturing Company.

b. Central Plastics Company.

c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

E. Dielectric-Flange Kits:

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:

1. Manufacturers:

a. Calpico, Inc.

b. Lochinvar Corporation.

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

G. Dielectric Nipples:

1. Manufacturers:

a. Grinnell Mechanical Products.

b. Perfection Corporation; a subsidiary of American Meter Company.

c. Precision Plumbing Products, Inc.

d. Sioux Chief Manufacturing Company, Inc.

e. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

## 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 brazed joints.

2. Standard weight, Type S, Grade B steel pipe, fully welded, with Class 150 wrought cast or forged steel flanges at equipment and valve connections only.

B. Makeup-water piping installed aboveground shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

C. Makeup-Water Piping Installed Belowground: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

D. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. 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 according to the piping manufacturer's written instructions.

F. Cryogen Vent Piping: Schedule 10 stainless steel or Type L (B) copper pipe for connecting to equipment connection for discharging to the outside 7 feet above the roof.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other

design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Cut pipe to measurements established at site and work into place with forcing or springing.

C. Piping shall be installed by skilled mechanics using designated basic materials plus any required supplementary materials.

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. Install piping to permit valve servicing.

H. Install piping at indicated slopes.

I. Install piping straight and true, free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install piping to allow application of insulation.

L. Select system components with pressure rating equal to or greater than system operating pressure.

M. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

N. 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.

O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

P. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the top of the main pipe.

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. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.3 PIPE GRADING

A. Equipment Drains: Each line from a relief valve, air vent valve, separator or a boiler, drip pan elbow, exhaust head, heat exchanger, compression tank, receiver, pump base, air conditioning unit pan, air washer overflow and drain, evaporator pan, and similar drain shall grade down to a point of open sight discharge and/or as indicated on the drawings.

3.4 HANGERS AND SUPPORTS

A. Piping support must account for expansion and contraction, vibration, dead load of piping and its contents, and seismic-bracing requirements.

B. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

C. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Use manufacturer's recommended methods and follow all applicable codes for joining each piping system.

C. Make square cuts on all pipes using proper tools and alignment devices. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

D. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. 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.

1. Use solder joint fittings in copper tubing lines.

2. Do not anneal copper tubing and fittings.

3. Tubing shall be cut square, and burrs shall be removed. Insides of fittings and outsides of tubing shall be well cleaned with steel wool, steel brushes, and/or emery cloth before assembly.

4. Installation shall be made by skilled mechanics in accordance with the material manufacturer's recommendations.

5. Mitering of joints for elbows and notching of straight runs for tees will not be permitted.

6. All joints shall be made with solid string or wire solder. Fluxes shall be non-corrosive pastes of the proper type. Solder shall be lead free. No cored solder will be permitted.

F. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

1. All joints shall be fusion welded by a metallic arc or gas welding process. Pipe ends shall be beveled 37½°. All welding operations shall conform to the latest recommendations of the American Welding Society or to the applicable provisions of the Code for Pressure Piping, ANSI B31.1, latest edition, amended to date.

2. Weld rods shall be of the proper type for each application to match the line materials.

3. If the Engineer so requests, the Contractor shall have each of his welders prepare test coupons which shall be tested in an approved independent testing laboratory and any defects found shall be cause for dismissal of the welder from the project. All cost of such tests shall be borne by the Contractor.

4. Branch takeoffs not larger than 2/3 of the main may be made using shaped nipples, weldolets, or threadolets to match branch line fabrication methods.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Copper Fittings

1. Use wrought copper solder joint type in all patterns and sizes available. Use long radius copper elbows wherever available and space will permit.

J. Welding Fittings

1. All fittings in welded lines shall be factory-fabricated welding fittings of the same material and the same weight or Schedule as the piping attached.

2. All elbow tees, caps and special fittings including connections into headers shall be standard butt welding fittings, conforming to ANSI B16.9, with the following exception: Branch take-offs from lines 2½" and larger and where the size of the takeoff does not exceed 2/3 of the normal diameter of the

mains to which connected, may be made with shaped nipples or with Bonney Weldolets or Threadolets as required by the class of fabrication.

3. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.

K. Flanges

1. At connections to flanged valves and equipment outlets in steel piping systems using welding neck, slip on welding flanges, screwed steel, or cast iron companion flanges.

   a. It will be permissible to use cast iron flanged fittings at connections to equipment items.

2. In grooved end piping systems use matching flanged adapter nipples.

3. In copper lines use brass flanges.

4. Connecting flanges shall have matching flat or raised faces. Faces shall be free of imperfections that would prevent proper seating.

5. Tighten bolts uniformly all around to prevent any stress.

L. Gaskets

1. Manufactured from proper materials as with performance and materials described in Division 23 "Common Work Results for HVAC", unless otherwise indicated. Full-faced type for flat-faced flanges and ring type for raised-faced flanges.

   a. Water Lines: Red rubber sheeting.

   b. Steam and Condensate Return Lines: Non-asbestos sheeting.

   c. Dielectric Flanges: As provided with the flanges.

   d. Other Lines: As recommended for the duty.

3.6 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for identification materials and installation.

B. Paint piping insulation as specified in Division 23 Section "Identification for HVAC Piping and Equipment".

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests on hydronic piping:

1. Procedures in subparagraphs below are paraphrased from ASME B31.9.

2. Test piping prior to backfilling, concealing, insulating or painting; isolate pressure sensitive equipment from tests.

   a. Test portions as required by construction schedule. When previously tested sections are expanded, retest at connections.

   b. Test new portions as required by construction schedule; test new connections into existing lines.

3. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Air may be substituted as a testing medium instead of water. Refrigerant lines shall be leak tested with air unless otherwise indicated.

4. 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.

5. Isolate expansion tanks and determine that hydronic system is full of water.

6. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

7. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.

8. Prepare written report of testing. All test results shall be submitted to the Owner and Architect. Provide all tests required by acceptable codes.

9. Furnish all compressed air, vacuum and water pumps; tanks of compressed air, nitrogen, carbon dioxide, refrigerant, gauges, plugs, seals, etc., as required to obtain, maintain and measure pressures during tests.

10. Pressure test all systems per governing codes, to a minimum of 1.5 times the working pressure, or the following table, whichever is greater:

| Piping System | Test Pressure (psig) |
|---|---|
| High Pressure Steam (above 15 psig) | 200 |
| Low Pressure Steam (15 psig and less) | 100 |
| Gravity Steam Condensate Returns | 100 |
| Pumped Steam Condensate Return | 200 |
| Heating, Chilled, and Condenser Water | 150 |
| Refrigerant | 450 |

11. 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.

3.8 REPAIRS

A. Effect repairs as recommended by the manufacturer of the pipe and fittings materials; replace any defective materials. When procedures involve additional work on a joint and they fail, remake the joint. Repair operations shall include:

1. Screwed Joints: Additionally tighten.

2. Caulked Joints: Additionally caulk.

3. Welded Joints: Chip out old weld metal and re-weld.

4. Compression Joints: Re-clean; replace seal, compression rings, couplings, etc.

5. Mechanical Joints: Re-clean; additionally tighten.

6. Soldered or Brazed Joints: Remake joint, no additional soldering or brazing allowed.

3.9 CLEANING

A. Clean all new piping systems and components prior to putting into service.

B. Heating Water Systems: Fill the entire system with a solution consisting of one pound of caustic soda or 3 pounds of trisodium phosphate per 100 gallons of water; heat to 150°F and circulate for 48 hours over at least a 3 day period; drain, flush with fresh water and refill with fresh water to which adequate amounts of suitable chemicals have been added.

C. Chilled and Condenser Water Systems: Fill the entire system with a solution consisting of one pound caustic soda or 3 pound of trisodium phosphate per 100 gallons of water; circulate for 60 hours over at least a 5 day period; drain, flush with fresh water and refill with fresh water to which adequate amounts of suitable chemicals have been added.

D. Steam and Condensate Return System: Clean all fittings and pipes before installation. After installation, blow out all steam lines with steam and repeat as necessary to insure all foreign particles are removed.

E. Blow off all strainers.

F. Waste and Drain Lines: Swab out lines; flush with fresh water.

G. Repetition: Repeat the above procedures until all parts of each piping system are thoroughly cleaned of all foreign materials.

**END OF SECTION**

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# SECTION 23 21 16

# HYDRONIC PIPING SPECIALTIES

## PART 1 - GENERAL

1.1 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Chilled-water piping.

2. Condensate-drain piping.

3. Air-vent piping.

4. Safety-valve-inlet and -outlet piping.

B. Related Sections include the following:

1. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for expansion fittings.

2. Division 23 Section "General-Duty Valves for HVAC Piping" for valves and accessories for piping.

3. Division 23 Section "HVAC Insulation – Duct, Equipment, and Piping" for pipe saddles at pipe hangers.

4. Division 23 Section "Steam and Condensate Heating Piping".

5. Division 23 Section "Steam and Condensate Heating Piping Specialties".

6. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic and wind restraint requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

2. Air-control devices.

3. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops,

and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.4 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.

1.5 QUALITY ASSURANCE

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein. All products to be purchased from Ferguson Enterprises.

1. Installer Qualifications: Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

a. 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 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding 150 psig minimum working pressure at the temperature listed below, unless otherwise indicated:

1. Chilled-Water Piping: 200 deg F.

2. Makeup-Water Piping: 200 deg F.

3. Condensate-Drain Piping: 200 deg F.

4. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers:

a. Armstrong Pumps, Inc.

b. Bell & Gossett Domestic Pump; a division of ITT Industries.

c. Flow Design Inc.

d. Griswold Controls.

e. Taco.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.

4. Plug: Resin.

5. Seat: PTFE.

6. End Connections: Threaded or socket.

7. Pressure Gage Connections: Integral seals for portable differential pressure meter.

8. Handle Style: Lever, with memory stop to retain set position.

9. CWP Rating: Minimum 125 psig.

10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers:

a. Armstrong Pumps, Inc.

b. Bell & Gossett Domestic Pump; a division of ITT Industries.

c. Flow Design Inc.

d. Grinnell Mechanical Products.

e. Griswold Controls.

f. Taco.

g. Tour & Andersson; available through Victaulic Company of America.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.

3. Ball: Brass or stainless steel.

4. Stem Seals: EPDM O-rings.

5. Seat: PTFE.

6. End Connections: Flanged.

7. Meter.

8. Handle Style: Lever, with memory stop to retain set position.

9. CWP Rating: Minimum 125 psig.

10. Maximum Operating Temperature: 250 deg F.

E. Automatic Flow-Control Valves:

1. Manufacturers:

a. Flow Design Inc.

b. Griswold Controls.

c. Nexus.

d. NuTech.

2. Body: Brass or ferrous metal.

3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.

4. Combination Assemblies: Include bonze or brass-alloy ball valve.

5. Identification Tag: Marked with zone identification, valve number, and flow rate.

6. Size: Same as pipe in which installed.

7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.

8. Minimum CWP Rating: 175 psig.

9. Minimum Operating Temperature: 200 deg F.

2.3 HYDRONIC PIPING SPECIALTIES

A. Strainer Perforations: All strainers shall be stainless steel and sized based on the service and installed pipe size as indicated by the table below, unless indicated otherwise.

1. Chilled and Heating Water Piping

a. Up to 2-inch: 0.033-inch Perforation

b. From 2.5-inch up to 4-inches: 0.057" Perforation

c. 6-inches and greater: 0.125" Perforation

2. Condenser Water Piping:

a. Up to 2-inch: 0.020-inch Perforation

b. From 2.5-inch up to 4-inches: 0.045" Perforation

c. 6-inches and greater: 0.100" Perforation

B. 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. CWP Rating: 125 psig (860 kPa).

C. 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. CWP Rating: 125 psig.

D. 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. CWP Rating: 750 psig.

E. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.

2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch (20-mm) misalignment.

4. CWP Rating: 150 psig (1035 kPa).

5. Maximum Operating Temperature: 250 deg F (121 deg C).

F. 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 (1035 kPa).

5. Maximum Operating Temperature: 250 deg F (121 deg C).

## PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

B. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

C. Install calibrated-orifice, balancing valves at each branch connection to return main where serving three or more terminal units. 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.

F. All valves shall be installed with stems in vertical position, unless otherwise indicated. If not possible, stems may be installed 45° off vertical position where allowed by manufacturer.

G. Install unions in piping**,** NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

H. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

I. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Refer to Division 23 Section "Hydronic Piping" for piping applications by system. Grooved fittings are not allowed on hot-water heating applications.

B. Select system components with pressure rating equal to or greater than system operating pressure.

C. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

D. Install automatic air vents where recommended at bladder type expansion tanks only.

E. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

F. 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.

G. Install expansion tanks on the floor or suspended as indicated. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

H. PT test plugs shall be located at each hydronic BAS temperature sensor and at the entering and leaving connections of coils, chillers, hot water boilers, and heat exchangers.

I. Provide facility with a PT measurement kit with thermometers and gauges chosen to indicate system pressures and temperatures at mid-scale.

**END OF SECTION**

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# SECTION 23 31 13

# METAL DUCTS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.

2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.

B. Related Sections include the following:

1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

2. Division 23 Section "Breechings, Chimneys, and Stacks".

3. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment".

1.2 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. NUSIG: National Uniform Seismic Installation Guidelines.

1.3 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.

2. Sealants and gaskets.

3. Seismic-restraint devices.

B. Shop Drawings: CAD-generated and drawn to same scale as contract drawings, minimum 1/8 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.

1. Shop drawings required for all areas of the building.

2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

3. Duct sizes shown on the drawings are net free area and indicate design intent. When obstructions occur within the duct from motorized actuators, damper frames, duct liner, etc., the duct size shall be increased to preserve free area design intent. Duct layout indicating the following:

   a. Sizes and pressure classes.

   b. Elevations of top and bottom of ducts.

   c. Dimensions of main duct runs from building grid lines.

   d. Fittings.

   e. Duct accessories, including access doors and panels.

   f. Notes indicating deviations from design intent for detailed review by Engineer.

4. Equipment installation based on equipment being used on Project.

5. Submit the following with the initial shop drawing package:

   a. Reinforcement and spacing.

   b. Seam and joint construction.

   c. Penetrations through fire-rated and other partitions.

   d. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

   e. Dampers

      1) Locations of fire-smoke dampers.

      2) Locations of motorized control dampers.

      3) Indication of location, size, and quantity of damper actuators in the air stream.

      4) Location of damper actuator access for maintenance and inspection.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings are required for all areas and shall remain on site. Coordinate with all trades.

B. Welding certificates.

C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

3. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."

1.7 DELIVERY, STORAGE, AND HANDLING

A. After fabrication and before the ductwork is installed it shall be "wiped clean" and "heat-shrink wrapped" or some other method of wrap for maintaining a clean ductwork system during delivery to and storage at the jobsite.

B. Deliver ducts with all openings protected and sealed. Maintain covered openings through shipping, storage, and handling to prevent entrance of dirt, debris, and moisture.

C. The area provided for duct storage at the jobsite shall be clean, dry and exposure to dust minimized.

## PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view and minimum 24 gage thickness.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 316 304, and having a No. 2D finish for concealed ducts and 2B for exposed ducts.

E. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

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.

2.2 DUCT FIRE WRAP

A. Fire wrap: An assembly providing at least a 2-hour fire rating for sheet metal ducts.

B. Manufacturers:

1. Pabco.

2. Unifrax: FyreWrap.

C. Quality Assurance: Comply with NFPA 96 and U.L. standards.

D. Where permitted by local codes, the products above may be a substitute for a 2-hour fire rated gypsum board covering.

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.

C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

E. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

2. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.

3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Nexus Inc.

c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, metal cleat, and gasket details.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Lockformer.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.

3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.6 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers:

a. McGill AirFlow Corporation.

b. SEMCO Incorporated.

c. Gowco, Inc.

d. Spiramir

e. National Duct Systems

C. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers:

a. McGill AirFlow Corporation

b. SEMCO Incorporated

c. Gowco, Inc.

d. Spiramir

e. National Duct Systems

D. Duct Joints:

1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.

2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.

3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.

a. Manufacturers:

1) Ductmate Industries, Inc.

2) McGill AirFlow Corporation.

3) SEMCO Incorporated.

E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

F. Diverging-Flow Fittings: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

G. Fabricate elbows using die-formed, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:

a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.

b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.

c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.

d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:

a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.

b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.

c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.

d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

4. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only.

5. Round Elbows Larger Than 9 Inches in Diameter: Fabricate pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows.

6. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.

7. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

H. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:

1. Round Elbows 4 to 8 Inches in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with PVC aerosol spray.

2. Round Elbows 9 to 26 Inches in Diameter: Standing-seam construction.

3. Round Elbows 28 to 60 Inches in Diameter: Standard welded construction.

4. Other Fittings: Welded joints.

5. Couplings: Slip-joint construction with a minimum 2-inch insertion length.

## PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

**1.** Primary Supply Ducts (before Air Terminal Units): 4-inch wg.

2. Secondary Supply Ducts (after Air Terminal Units): 1-inch wg.

3. Return Ducts (Negative Pressure): 2-inch wg.

4. Exhaust Ducts (Negative Pressure): 2-inch wg.

5. Range Hood Exhaust Ducts (Negative Pressure): 5-inch wg.

6. All other undesignated ducts: the static pressure of the connected fans, positive or negative based on service.

B. All ducts shall be galvanized steel except as follows, unless otherwise indicated:

1. Range Hood Exhaust Ducts: Comply with NFPA 96.

a. Concealed: Carbon-steel sheet.

b. Exposed: Type 304, stainless steel with finish to match kitchen equipment and range hood.

c. Fully weld all seams and joints.

2. Wet Exhaust Service Ducts:

a. Construction:

1) Exposed Locations: Type 304, 18 gage stainless steel with #4 finish to match kitchen equipment and range hood. Fully weld all seams and joints. All seams ground and polished.

2) Concealed Locations: 24 gage aluminum, welded with seams and laps arranged on top of duct or continuously welded stainless steel as described for exposed locations.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install ducts with fewest possible joints.

C. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

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. Provide break away flange for all stainless steel ductwork at fire/smoke damper interfaces. Install stainless steel drain pans extending beyond in all directions with automatic condensate pumps and piping to nearest code approved drain at break away.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.

O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.", unless otherwise indicated.

P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

Q. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections. Painting not required for ducts serving mechanical, electrical and data rooms.

R. Provide temperature range for duct mounted thermometer dials: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

## 3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for ducts, per Seal Class 'A'.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Support Ducts per SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for ducts.

F. Do not use powder-actuated concrete fasteners.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. The leak testing shall be observed by the General Contractor's representative and the Owner's representative. Provide 48 hours notification of such tests.

B. All ducts shall be tested. Submit a written report. The contractor is required to maintain on-site a set of ductwork prints that are shaded in different colors to show the duct section isolated for each test. Also, the Contractor shall indicate on the print the date each section of duct was tested and the final percent leakage rate measured for each test section.

C. If any duct section fails the leakage test, the contractor shall repair the leakage and re-perform the leakage test.

D. The duct systems shall be pressure tested for leaks at their specified pressure ratings and shall be within the maximum allowed by the following:

1. Primary Air (medium pressure ducts) Systems – 3% leakage.

2. Other Systems – 2% leakage.

E. The leakage test shall be performed using a kit as furnished by United McGill Corp. or approved equal and shall include the following components:

1. Blower

2. Two manometers or U-tubes

3. Calibrated orifice tube

F. The leakage test procedure is as follows:

1. Carefully seal off all openings (except one for connecting the test equipment) to the duct run-out section to be tested.

2. Connect the downstream end of the orifice tube to the duct system using a piece of flexible tubing.

3. Connect one manometer to the static taps on the tube to read orifice differential pressure. Connect the other manometer to a 5/16" tap in the duct at least one foot from the blower connection to read test static pressure.

4. Attach the blower to the orifice tube and block off the inlet to prevent over pressurizing a tight system.

5. Start the blower and slowly open the inlet until the desired test static pressure is reached. Let the blower run for at least one minute to insure a steady state.

6. At this point, the air flowing through the orifice tube is going into the duct system and is equal to the amount leaking out. This leakage rate can be read from the calibration chart on the orifice tube. This measured cfm is used to determine the leakage percent.

7. If the duct system is too large and the allowable leakage is greater than the capacity of the blower, the system shall be tested in several sections and the results added together.

3.7 DUCT CLEANLINESS AND DUCT CLEANING

1. DUCT CLEANLINESS

a. It is the intent to provide an installation of a ductwork system that appears to be visibly clean.

b. A visual inspection of porous and non-porous ductwork components must be monitored by the Contractor to ensure that the system is visibly clean. The system has excessive dust or debris when an accumulation of particles can be observed in the ductwork. An interior surface is considered visibly clean when it is free from non-adhered substances and debris.

c. Cleanliness verification shall be performed after the ductwork system has been "wiped clean" and prior to the application of any piece of equipment or component being used in operation.

d. If air handling units are operated without the pre-filters and the final filters in place, the ductwork shall be replaced or vacuumed per Article B "Cleaning New Systems" below.

2. Condition of new ductwork shall include the following measures:

a. Any internal exposed mastic sealant to be removed.

b. The light coating of oil on machine formed sheet metal ductwork is to be removed.

c. The discoloration marks from the plasma cutting process must be removed.

d. Before installation of the individual duct sections they are to be visually inspected for dust and/or debris, and wiped clean, if necessary.

e. After the ductwork has been installed, the cleanliness procedure shall be to temporarily cover the open ends of the ductwork to prevent dust and debris of finding its way to the system.

f. If vacuuming is required to adequately clean the ductwork, the vacuum cleaner must be HEPA filtered and capable of achieving a minimum of 40 inches of water gage. The vacuum should be fitted with a 2.5" round nylon brush attached to a 1.5" diameter vacuum hose.

3. Conditions of existing ductwork and equipment within the systems that serve the renovated areas shall be visually inspected for dust and debris.

a. If dust and/or debris is observed within the existing system, it shall be cleaned to remove all visual dust and debris. This process may include the addition of access doors to facilitate the "wiping" and/or "vacuuming" of the ductwork systems.

b. The system cleanliness procedures shall be adhered to during the construction process of the renovations.

c. New ductwork required for additions within the existing renovated area shall follow the procedures addressed above for the new ductwork.

d. If vacuuming is required to adequately clean the ductwork, the vacuum cleaner must be HEPA filtered and capable of achieving a minimum of 40 inches of water gage. The vacuum should be fitted with a 2.5" round nylon brush attached to a 1.5" diameter vacuum hose.

B. CLEANING NEW SYSTEMS

1. Mark position of dampers and air-directional mechanical devices before cleaning and perform cleaning before air balancing.

2. Use service openings, as required, for physical and mechanical entry and for inspection.

    a. Create other openings to comply with duct standards.

    b. Disconnect flexible ducts as needed for cleaning and inspection.

    c. Remove and reinstall ceiling sections to gain access during the cleaning process.

3. Vent vacuuming system to the outside. Include HEPA filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

4. Clean the following metal duct systems by removing surface contaminants and deposits:

    a. Air outlets and inlets (registers, grilles, and diffusers).

    b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

    c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

    d. Coils and related components.

    e. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.

    f. Supply-air ducts, dampers, actuators, and turning vanes.

5. Mechanical Cleaning Methodology:

    a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

    b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

    c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

    d. Do not permit fibrous-glass duct liner to get wet. Remove and replace wet duct liner.

e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Cleanliness Verification:

a. Visually inspect metal ducts for contaminants.

b. Where contaminants are discovered, re-clean and reinspect ducts.

C. CLEANING EXISTING SYSTEMS

1. Use service openings, as required, for physical and mechanical entry and for inspection.

a. Use existing service openings where possible.

b. Create other openings to comply with duct standards.

c. Disconnect flexible ducts as needed for cleaning and inspection.

d. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.

e. Remove and reinstall ceiling sections to gain access during the cleaning process.

2. Mark position of dampers and air-directional mechanical devices before cleaning and restore to their marked position on completion.

3. Particulate Collection and Odor Control:

a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.

b. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

4. Clean the following metal duct systems by removing surface contaminants and deposits:

a. Air outlets and inlets (registers, grilles, and diffusers).

b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain

pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

d. Coils and related components.

e. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.

f. Supply-air ducts, dampers, actuators, and turning vanes.

g. Dedicated exhaust and ventilation components and makeup air systems.

5. Mechanical Cleaning Methodology:

a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

f. Provide operative drainage system for washdown procedures.

g. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

6. Cleanliness Verification:

a. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.

b. Visually inspect metal ducts for contaminants.

c. Where contaminants are discovered, re-clean and reinspect ducts.

7. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

    a. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.

    b. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

8. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

**END OF SECTION**

# SECTION 23 33 00

# AIR DUCT ACCESSORIES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Turning vanes.

2. Duct-mounting access doors.

3. Flexible connectors.

4. Flexible ducts.

5. Duct accessory hardware.

B. Related Sections include the following:

1. Division 23 Section "Instrumentation and Control for HVAC" for electric and pneumatic damper actuators.

2. Division 23 Section "Metal Ducts" for duct construction and fittings.

1.2 DEFINITIONS

A. Low Leakage: Class 1A as defined by AMCA Standard 511, equating to less than 3cfm/ft2of damper area, at differential pressure of 1-inch wgess than 8cfm/ft2of damper area, at differential pressure of 4-inch wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Turning vanes.

2. Duct-mounting access doors.

3. Flexible connectors.

4. Flexible ducts.

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. Special fittings.

2. Manual-volume damper installations.

3. Motorized-control damper installations.

4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.

5. Identify duct velocity and pressure class of duct system dampers are installed in.

6. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.6 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. Fusible Links: Furnish quantity equal to 10 percent, rounding up, for each type of amount installed with a minimum of one.

## PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

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.

2.2 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch-wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Duro Dyne Corp.

c. Dynasonics.

d. I.A.C.

e. METALAIRE, Inc.

f. SEMCO.

g. Ward Industries, Inc.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill, with Mylar or Tedlar wrap around fill.

D. Acoustic Elbows: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill, with Mylar or Tedlar wrap around fill.

2.3 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Manufacturers:

a. American Warming and Ventilating.

b. Ductmate Industries, Inc.

c. Flexmaster U.S.A., Inc.

d. Greenheck.

e. McGill AirFlow Corporation.

f. Nailor Industries Inc.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Provide number of hinges and locks as follows:

a. Less Than 12 Inches Square: Secure with two sash locks.

b. Up to 18 Inches Square: Two hinges and two sash locks.

c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.

d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Flexmaster U.S.A., Inc.

2. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Single or double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.

1. Manufacturers:

a. American Warming and Ventilating.

b. Ductmate Industries, Inc.

c. Greenheck.

d. KEES, Inc.

e. McGill AirFlow Corporation.

f. Nexus PDQ.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.4 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Ductmate Industries, Inc.

2. Duro Dyne Corp.

3. Ventfabrics, Inc.

4. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with NFPA 90A & 90B.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 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. Select metal compatible with ducts.

D. 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.

E. 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.

F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd.

2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.

3. Service Temperature: Minus 67 to plus 500 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.

2.5 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc.

2. Thermaflex.

B. Insulated Flexible Ducts: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation with a minimum value of R-6; polyethylene or aluminized vapor barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.

2. Minimum Air Velocity Rating: 4000 fpm.

3. Temperature Range: Minus 20 to plus 175 deg F.

C. Metal Lined Insulated Flexible Ducts: UL 181, Class 1, Triple locked aluminum inner core; fibrous glass insulation with a minimum value of R-6.

1. Pressure Rating: 6-inch wg (1500 Pa) positive and 2-inch wg (500 Pa) negative.

2. Minimum Air Velocity Rating: 4000 fpm.

3. Temperature Range: Minus 20 to plus 250 deg F insulated Fabric Ducts: UL 181, Class 1, with Chlorinated Polyethylene (CPE) inner core supported by helical wound galvanized steel; fibrous-glass insulation with a minimum R-6 value.

4. Pressure Rating: 6-inch wg (1500 Pa) positive and 2-inch wg (500 Pa) negative.

5. Minimum Air Velocity Rating: 4000 fpm.

6. Temperature Range: Minus 20 to plus 250 deg F Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a

worm-gear action or Nylon strap, in sizes 3 through 18 inches to suit duct size.

2.6 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 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Where damper actuators are located in the air stream, increase duct free area to maintain design intent.

C. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

D. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Install duct test holes where indicated and required for testing and balancing purposes.

G. Install remote dampers a minimum of 5 feet, or two duct diameters, whichever is greater, before air device.

H. Remote dampers shall include controller box as approved by architect.

I. Provide test holes at fan inlets and outlets and elsewhere as indicated.

J. Install fire and smoke dampers, with reset operators or fusible links, according to manufacturer's UL-approved written instructions.

K. Install duct silencers rigidly to ducts.

L. Install duct heaters square to duct and perpendicular to air travel. Provide disconnecting means at heater.

M. Connect duct discharge temperature sensor downstream of duct heater.

N. Connect controlling thermostat or control cable to duct heater.

O. Install turning vanes in all square elbows, except for combustion air, dryer vent, and grease duct services, unless otherwise indicated.

P. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

Q. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

R. Connect terminal units to supply ducts.

S. Connect diffusers or light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

T. Do not use flexible ducts to change directions.

U. Connect flexible ducts to metal ducts with draw bands.

V. Flexible duct may only be installed above hard ceilings with direct access to all both ends of the flexible duct runs. Flexible duct shall not be installed more than 24" inside a hard ceiling edge or transition.

3.2 DUCT ACCESS DOOR APPLICATIONS

A. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.

2. Downstream from volume dampers, motorized dampers, and equipment.

3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.

4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.

5. On sides of ducts where adequate clearance is available.

6. Upstream and downstream of attenuators.

B. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 8 inches.

2. Two-Hand Access: 12 by 12 inches.

3. Head and Hand Access: 18 by 18 inches.

4. Head and Shoulders Access: 24 by 18 inches.

5. Body Access: 30 by 24 inches.

6. Body Plus Ladder Access: 30 by 24 inches.

C. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter.

2. Two-Hand Access: 10 inches in diameter.

3. Head and Hand Access: 12 inches in diameter.

4. Head and Shoulders Access: 18 inches in diameter.

5. Body Access: 24 inches in diameter.

D. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.3 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

**END OF SECTION**

# SECTION 23 37 13

# DIFFUSERS, REGISTERS, AND GRILLES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate drawing designation, model number, size, materials of construction, finish, and mounting details; and performance data including throw and drop, accessories, static-pressure drop, and noise ratings.

2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, model number, size, and accessories furnished.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Price Industries.

B. Titus.

C. Anemostat

D. Precision Air Products

2.2 CAPACITIES AND CHARACTERISTICS

A. Provide Grilles, Registers, and Diffusers with capacities and characteristics as indicated in the drawings.

B. Maximum NC shall be 25 at CFM indicated, including neck damper.

C. Coordinate frame style with drawings.

D. Finish: Baked enamel, color selected by Architect.

E. Ceiling mounted critical environment grilles, registers, and diffusers shall have an independent hanger or chain to structure.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles 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, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

C. Deliver and store clean and shrink wrapped. Touch up any paint damage.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Install insulation blankets on the back-pan of all air devices directly under an exposed roof. Refer to Division 23 "HVAC Insulation".

E. At each ceiling and sidewall take-off from a duct, install an adjustable volume extractor with appropriate operator. Refer to Division 23 "Air Duct Accessories".

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

## END OF SECTION

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# SECTION 23 51 00

# BREECHINGS, CHIMNEYS, AND STACKS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Listed double-wall vents.

B. Related Sections include the following:

1. Division 23 Section "HVAC Fans" for induced-draft and mechanical fans and for motorized and barometric dampers.

2. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic and wind restraint requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Type B and BW vents.

2. Type L vents.

3. Special gas vents.

4. Building-heating-appliance chimneys.

5. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.

2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: 10 years from date of Substantial Completion.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. American Metal Products; MASCO Corporation.

2. Metal-Fab, Inc.

3. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

2.2 LISTED TYPE B AND BW VENTS

A. 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.

B. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.

C. Inner Shell: ASTM B 209, Type 1100 aluminum ASTM B 209, Type 3003 aluminum ASTM B 209, Type 3105 aluminum ASTM A 666, Type 430 stainless steel.

D. Outer Jacket: Aluminized steel.

2.3 LISTED TYPE L VENTS

A. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F continuously, or 1700 deg F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 2-inch airspace filled with high-temperature, ceramic-fiber or mineral-wool insulation.

C. Inner Shell: ASTM A 666, Type 304 stainless steel.

D. Outer Jacket: Stainless steel.

E. 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 90 percent of rainfall.

2. Termination: Round chimney top designed to exclude 98 percent of rainfall.

3. Termination: Exit cone with drain section incorporated into riser.

2.4 LISTED SPECIAL GAS VENTS

A. 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.

B. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.

C. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

D. Outer Jacket: Stainless steel.

2.5 LISTED BUILDING-HEATING-APPLIANCE FLUES AND CHIMNEYS

A. Description: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F continuously, or 1800 deg F for 10 minutes; with positive or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 2-inch annular space filled with high-temperature, ceramic-fiber insulation.

C. Inner Shell: ASTM A 666, Type 304 stainless steel.

2.6 ACCESSORIES

A. General: 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.

B. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

2.7 GUYING AND BRACING MATERIALS

A. Cable: Galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch in diameter.

2. For ID Sizes 4 to 15 Inches: 5/16 inch.

3. For ID Sizes 18 to 24 Inches: 3/8 inch.

4. For ID Sizes 27 to 30 Inches: 7/16 inch.

5. For ID Sizes 33 to 36 Inches: 1/2 inch.

6. For ID Sizes 39 to 48 Inches: 9/16 inch.

7. For ID Sizes 51 to 60 Inches: 5/8 inch.

B. Pipe: Galvanized steel, NPS 1-1/4.

C. Angle Iron: Galvanized steel, 2 by 2 by 0.25 inch.

D. Delegated Design: Size and locate the guying and bracing system with the materials above in compliance with Division 23 "Vibration Isolation and Seismic Controls for HVAC" and with the approval of a registered structural engineer in good standing.

## 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.

1. 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 Type L Vent: Vents for low-heat appliances.

C. Listed Special Gas Vent: Condensing gas appliances.

D. Listed Building-Heating-Appliance Flues and Chimneys:

1. Dual-fuel boilers, oven vents, water heaters, fireplaces and other solid-fuel-burning appliances: from equipment discharge to final point of exhaust termination.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. For condensing appliances, lap joints in direction of condensate 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.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

**END OF SECTION**

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# SECTION 26 05 00

# COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 - GENERAL

1.1 SUMMARY

A. The requirements contained in this Section apply to all Sections of this Division.

B. Section Includes:

1. Common terminology and requirements used throughout this Division.

2. Requirements for Acceptance Testing Agency.

3. Requirements for Professional Engineers responsible for Delegated Design.

4. Electrical equipment coordination and installation.

5. Sleeves for raceways and cables.

6. Sleeve seals.

7. Grout.

8. Common electrical installation requirements.

1.2 DEFINITIONS

A. AHJ: Authorities Having Jurisdiction.

B. ANSI GRAY: Where this Section and other Sections of this Division use the term "ANSI GRAY" it shall mean the manufacturer's standard ANSI Gray.

C. Bound Material: Bound refers to materials permanently bound, as by stitching or glue, or materials securely fastened in their covers by multiple fasteners that penetrate all papers. Ring binders, spiral binders, brads and screw posts are acceptable fasteners. Loose papers clipped together or stapled at one corner are not acceptable.

D. Business Day: Where this Section and other Sections of this Division use the term "Business Day" it shall mean Monday thru Friday, excluding Holidays recognized by Federal, State and Local government.

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

F. FMS: Facility management system.

G. NETA ATS: Acceptance Testing Specification, as published by InterNational Electrical Testing Association.

H. NBR: Acrylonitrile-butadiene rubber.

I. NIST: National Institute of Science and Technology.

J. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

K. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

L. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.3 INNOVATION MEMORANDUMS

A. The Owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.

1. Innovation Memorandum No. 5: All lighting fixtures and accessories to be purchased from Graybar Electric Supply in Nashville, TN. Contact Charlie Shannon, office (615) 743-3226, or email HCA@graybar.com. Refer to Division 26 Sections "Interior Lighting".

2. Innovation Memorandum No. 16: Electrical products including, but not limited to, power distribution, wire, and conduit to be purchased from Graybar – Nashville. Contact Charlie Shannon, 825 8th Avenue South, Nashville, TN 37217, (615) 743-3226, or email HCA@graybar.com. Refer to Division 26 Sections:

a. "Low-Voltage Electrical Power Conductors and Cables"

b. "Grounding and Bonding for Electrical Systems"

c. "Hangers and Supports for Electrical Systems"

d. "Raceways and Boxes for Electrical Systems"

e. "Vibration and Seismic Control for Electrical System"

f. "Identification for Electrical Systems"

g. "Overcurrent Protective Device Coordination Study"

h. "Wiring Devices"

i. "Enclosed Switches and Circuit Breakers"

j. "Enclosed Controllers"

3. Innovation Memorandum No. 25: Project shall comply with 2022r2 MEP Guidelines.

1.4 PERFORMANCE REQUIREMENTS

A. The Drawings diagrammatically show the sizes and locations of various equipment and devices, and the sizes of the major interconnecting wires, without showing exact details as to elevations, offsets, control wiring and other installation requirements. Carefully layout the Work at the site to conform to the architectural and structural conditions, to avoid obstructions and to permit proper grading of pipe associated with other portions of the Work. In cooperation with other trades, determine the exact location of equipment and devices and connections thereto by reference to the submittals and rough-in drawings, and by measurements at the site. Make minor relocations necessitated by the conditions at the site, or directed by the Owner, without additional cost to the Owner.

1.5 SUBMITTAL PROCEDURES

A. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Submit Product Data in electronic format. Files shall be provided in Portable Document Format (.pdf).

a. Submit digital copies of Product Data as required under Division 01.

b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique section identification heading for ease of navigation.

2. In addition to digital copies, hardcopies of Product Data may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

3. Product Data shall not consist of manufacturer's catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.

B. Common Requirements for Shop Drawings and Coordination Drawings: Where this Section and other Sections of this Division require Shop Drawings or Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section "Project Management and Coordination". In addition to the requirements of Division 01 comply with the following:

1. Prepare Shop Drawings and Coordination Drawings in accordance with project's approved BIM Management Plan.

2. Prepare Shop Drawings and Coordination Drawings using computerized modeling software compatible with AutoDesk's Revit®, AutoCAD®, or

Navisworks®. Drawings files must be composite with multiple distinctive layers for each of the various trades.

3. Shop Drawings and Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.

4. Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.

5. Submit Shop Drawings and Coordination Drawings in electronic format. Files shall include both AutoDesk® compatible source files and files printed to Portable Document Format (.pdf).

   a. Submit digital copies of Shop Drawings and Coordination Drawings as required under Division 01.

   b. Bookmark Portable Document Format (.pdf) files of digital copies with a unique sheet identification number for ease of navigation.

6. In addition to digital copies, hardcopies of Shop Drawings or Coordination Drawings may be required, verify with Division 01. If hardcopies are required, they shall have each sheet clearly labeled with a unique sheet identification number.

C. Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for "Other Informational Submittals". In addition to the requirements of Division 01 comply with the following:

1. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with "Compliance". Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

   a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.

   b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.

   c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.

d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.

D. Common Requirements for Qualification Data:

1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of registration in the Project location.

1. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; Submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

1.6 ACTION SUBMITTALS

A. Product Data: Submit product data for each of the following.

1. Sleeves.

2. Sleeve seals.

3. Grout.

1.7 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:

1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.

2. Reflected Ceiling Plans: ceiling plans, sections, and other necessary details showing dimensioned layouts for equipment located in or on the ceiling plane. Base dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

a. Suspended ceiling components.

b. Structural members to which suspension systems for luminaires will be attached.

c. Perimeter moldings, decorative ceiling elements, and Architectural features.

d. Luminaires.

e. HVAC Diffusers, Registers and Grilles.

f. Speakers.

g. Sprinklers.

h. Fire Alarm initiating devices, including but not limited to the following:

1) Smoke detectors.

2) Heat detectors.

3) Flame detectors.

i. Fire Alarm notification appliances.

j. Occupancy sensors.

k. Access panels.

l. Security cameras and occupancy detectors.

3. Electrical Equipment Layouts: Floor plans, elevations, and other necessary details showing dimensioned layouts for spaces containing electrical equipment. Base electrical equipment dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the following items coordinated with each other, based on input from installers of the items involved:

a. Electrical equipment layout and relationships between components and adjacent structural and mechanical elements.

b. Indication of required working clearances and required area above and around electrical equipment where pipes and ducts are prohibited.

c. Location of Conduit entry into electrical equipment.

d. Location of luminaires, sprinkler piping and heads, ducts, and diffusers.

e. Electrical equipment support locations, type of support, and weight on each support.

f. Location of structural supports for structure-supported raceways.

g. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

1.8 QUALITY ASSURANCE

A. Common Requirements for Independent Testing and Inspecting Agency Qualifications: Where this Section and other Sections of this Division call for an Independent Testing and Inspecting Agency (Testing Agency); the Testing Agency shall comply with the following requirements:

1. Have the experience and capability to conduct the testing indicated,

2. Be a member company of the InterNational Electrical Testing Association (NETA) or a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction and the Engineer-of-Record.

3. Meet the Requirements of NETA ATS 3.0 including, but not limited to, the following:

a. Be an independent, third-party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.

b. Be regularly engaged in the testing electrical equipment devices, installations, and systems.

c. Use technicians who are regularly employed for testing services.

d. Have a "Full Membership" classification issued by the InterNational Electrical Testing Association meets the above criteria.

4. Testing Agency's Field Personnel: Technicians performing specified electrical tests and inspections shall meet the Requirements of NETA ATS 3.0 including, but not limited to, the following:

a. Technicians performing specified electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.

b. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, Standard for Certification of Electrical Testing Personnel. Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.

B. Common Requirements for Material Quality: Materials, equipment and devices shall be new and of the quality specified and shall be free from defects at the time of installation. Materials, equipment, and devices damaged in shipment or

otherwise damaged or found defective prior to acceptance by the Owner shall be replaced with new materials, equipment or devices identical with those damaged, unless approved otherwise by the Owner in writing.

C. Common Requirements for Code Compliance: In case where differences occur between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents, the most stringent shall govern. Perform the following:

1. Promptly notify the Architect in writing of any such difference.

2. Obtain approval from Architect before proceeding with the Work.

3. Should the Contractor perform any work that knowingly does not comply with local codes, laws and ordinances, industry standards, or other governing regulations; the Work shall be corrected at no cost to the Owner.

D. Common Requirements for Compliance with AHJ Instructions: In cases where the Authority Having Jurisdiction requires deviations from the requirements of the Contract Documents, perform the following:

1. Promptly notify the Architect in writing of any such difference.

2. Obtain approval from Architect before proceeding with the Work.

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

1. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided shall meet the requirements of the UL standard.

1.9 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01 Section "Product Requirements".

1. If item of equipment or device offered as Substitution differs in dimension or configuration from that indicated in the Contract Documents, provide, as part of the substitution submittal, a drawing that shows that the equipment or devices proposed for Substitution can be installed in the space available without interfering with other trades or with access requirements for operations and maintenance in the completed project. Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.

2. Where substitute equipment or devices requires different arrangement or connections from that indicated in the Contract Documents, install the equipment or devices to operate properly and in accordance with the requirements of the Contract Documents. Make incidental changes necessary in piping, ductwork or wiring which results from the inclusion of the substitute

equipment or device without any additional cost to the Owner. Pay all additional costs incurred by other trades in connection with changes required by the inclusion of the substituted equipment or device in the Work.

1.10 PROJECT CONDITIONS

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 Construction Manager and Owner no fewer than five business days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

B. Schedule of Work in Existing Facilities:

1. The building will continue in use throughout the construction period, carry out the Work in such a manner as to minimize disturbance to the occupants.

2. The schedule contemplates working in designated areas in the existing building while other adjacent areas are still being occupied. Carry out the Work in such a manner as to minimize disturbance to those occupied areas.

3. Should the Work in the designated areas affect any services to the areas that are to remain in use, new permanent or temporary services or a combination of both shall be installed as required to enable those occupied areas to function properly and without interruption.

4. Perform no work in the existing building which would interfere with its use during normal hours of occupancy, including but not limited to operations which would cause objectionable noise or service interruptions, unless special permission is granted by the Owner.

C. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving large equipment into place. Where any piece of equipment is too large for ingress through normal building openings it shall be placed in its containing space before the enclosing structure is completed.

D. Temporary Power: Where temporary power is required during the construction period, comply with ANSI/NECA 200 "Recommend Practice for Installing and Maintaining Temporary Power at Construction Sites."

1.11 COORDINATION

A. In describing various materials, equipment and devices, in general each item may be described singularly, even though there may be a multiplicity of identical items. Also, where the description is general in nature, the exact sizes, duties, space

arrangements, horsepower and other requirements must be obtained by reference to other portions of Contract Documents.

B. Space allocations for materials, equipment and devices have been made on the basis of present and known future requirements and the dimensions of items of equipment or devices of a particular manufacturer. Verify that all materials, equipment and devices proposed for use on this Project are within the constraints of the allocated space.

C. 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, ductwork and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

E. Utility Service Coordination:

1. Electrical Service: Coordinate the location of the electrical service entrance with the electric utility company and with other trades. Provide materials and equipment required to connect the electrical service.

F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

G. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

H. For roof-mounted equipment: Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

## PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

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

## PART 3 - EXECUTION

3.1 EXAMINATION

A. The Drawings do not indicate existing installations other than to identify modifications or extensions thereto. Visit the site and ascertain the existing conditions. Review construction details of the existing portion of the building during the site inspection. Include all work required to remove or modify portions of the existing installation in order to accommodate the new Work. Failure to comply with this will not be considered grounds for additional payment in connection with removing or modifying any part of the existing installation or installing any new or temporary work.

3.2 TEMPORARY WORKING ACCESS

A. Remove existing wire, conduit, equipment, fixtures, and other items as required to provide access for Work in existing facilities.

B. Reinstall and refinish items removed, or otherwise damaged, to match existing adjacent conditions upon completion of the Work.

3.3 SALVAGE, DEMOLITION AND RELOCATION

A. Modify, remove, salvage, or relocate materials, equipment and devices as indicated or required by the installation of new Work.

B. Salvage and Demolition: Working jointly with the Owner's Representative, establish and mark salvage and demolition items before commencing work; report items scheduled for relocation, reinstallation or reuse, which are found to be in damaged condition; await further instructions from the Owner before commencing Work.

1. Demolition material shall be removed from the site and disposed of in a legal manner.

2. Salvaged equipment and devices shall be the property of the Owner, unless otherwise indicated. Store salvaged items in locations as directed by Owner.

3. For devices and equipment marked for demolition, remove all conduit and wiring back to the point of origination, unless otherwise indicated.

4. Where existing walls are demolished, remove all existing electrical devices, their associated conduit and wiring back to the point of origination.

5. Where entire circuits are removed, turn the circuit breaker off and label as "spare".

6. Maintain service to all "existing to remain" devices and equipment that may be interrupted during demolition.

7. Upon completion of demolition, ensure that remaining devices that may have been interrupted during demolition are energized.

C. Relocations: Make minor relocations necessitated by the conditions at the site or as directed by the Owner's Representative, without additional cost to the Owner.

1. Remove items which are to be relocated in reverse order to original assembly or placement.

2. Protect items until relocation is complete.

3. Clean, Repair and restore to good functional condition, equipment, materials and items scheduled for relocation. Provide new fittings and appurtenances required to complete the relocations and to restore to good operating order.

D. Substitution of New materials for Relocation: New materials of similar design and quality may be substituted for materials and items indicated to be relocated upon approval of Owner and Architect. Comply with Division 01 for Substitution Procedures.

3.4 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. All materials, equipment and devices shall be installed in accordance with the recommendations of their manufacturer.

B. Comply with NECA 1 - Standard Practices for Good Workmanship in Electrical Construction, as published by the National Electrical Contractors Association.

C. Use licensed technicians skilled in their respective trades for installation of the Work.

D. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless otherwise indicated.

E. 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.

F. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a manner as to facilitate future disconnecting with minimum interference with other items in the vicinity.

G. Right of Way: Give to piping systems installed at a required slope.

H. Access Panels: Provide wall and ceiling access panels for unrestricted access to all concealed electrical equipment items and devices installed behind furrings, chases or non-removable suspended ceilings. Access Panel materials and installation requirements are specified in Division 08 Section "Access Doors and Frames."

I. Installation Inspections and Certifications

1. Obtain timely inspections of the installation by Authorities Having Jurisdiction. Remedy any deficiencies to the satisfaction of the inspecting official.

2. Upon final completion of the Work, obtain certificates of acceptance from the Authorities Having Jurisdiction. Deliver the certificates to the Owner.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves where cable or conduit penetrations occur. Install sleeves during erection of slabs and walls.

1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

2. Exception: Slab-on-grade construction shall not require sleeves or curbed formed openings when conduits or pipes that penetrate the slab-on-grade are installed and properly supported prior to the pouring of the slab.

C. Masonry Walls: Install sleeves where cable or conduit penetrations occur. Install sleeves during erection of walls.

1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

F. Non Fire-Rated Assemblies: Install sleeves where cable penetrations occur. Install sleeves during erection of walls.

1. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors a minimum of 2 inches above finished floor level.

I. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless otherwise indicated or.

J. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

2. Apply approved joint compound for gypsum board assemblies where masonry or concrete wall is faced on interior side with gypsum board.

K. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

L. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

M. Roof-Penetration Sleeves: Seal penetration of individual conduits and cables with flashing units applied in coordination with roofing work. Provide flashing unit as specified in Division 07 Section "Sheet Metal Flashing and Trim".

N. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.

O. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.6 OPTION TO RELOCATE DEVICES

A. The location of power, wall switches and other similar devices along with their associated connections may be relocated at the Owner's option, at no additional cost to the Owner, to a point within 10 feet of their present location provided the Contractor is notified prior to rough-in or installation.

3.7 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use 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.

3.8 UTILITIES

A. The location and voltage of electrical lines included within the Work are indicated in the Contract Documents in accordance with information furnished by the Owner. Existing utility lines not indicated in Contract Documents but encountered during construction shall be protected, relocated or capped as directed by the Owner.

B. Prior to excavation, examine the site and verify the location and elevation of all utilities and their relation to the Work. Identify and label all underground utilities

occurring within the bounds of the area to be excavated. Contact the known utilities and engage a certified locator service to assist in this effort.

C. Prior to excavation, contact the known utilities and inform them of excavation work plan. Proceed with excavation only after receiving approval from Utilities.

D. All precautions shall be exercised to prevent damage to existing lines, but should work become necessary, it must be authorized prior to execution except in an emergency situation.

E. Should damage result to any utility through the Contractor's negligence or failure to comply with the above directives, the Contractor shall bear the sole responsibility to correct such damage and shall be responsible for all expenses incurred in the expeditious repair or replacement of such damaged Utilities.

F. Repair of damaged utilities shall be to a condition equal to or better than the adjacent undamaged portion of such utility and to the complete satisfaction of the Owner and respective Utility.

3.9 CONNECTIONS

A. Phase Rotation: Prior to installing any connections or energizing any equipment, perform Phase Rotation verification test at the following:

1. Utility Transformers

2. Engine Generators

3. Motors

4. Connections to existing electrical equipment.

B. Mechanical Controls: Provide 120VAC power connections as required to components of Mechanical Control system. Coordinated quantity of circuits, connection requirements and locations between trades and with provisions of Divisions 21, 22, and 23 sections.

C. HVAC Terminal Boxes: Where the Drawings indicate a 120VAC circuit in a general area and labeled for terminal boxes (VAV, etc.), the intent is for this circuit to be extended and connected to the terminal box in that general area. Coordinate connection requirements and locations between trades and with provisions of Division 23 Sections and Drawings.

D. Smoke Dampers: Where the Drawings indicate a 120VAC circuit in a general area and labeled for dampers, the intent is for this circuit to be extended and connected to the Smoke and Fire/Smoke dampers in that general area in coordination with the smoke control sequence. Coordinated connection requirements and locations between trades and with provisions of Division 23 Sections and Drawings.

E. Security and Access Control: Where the Drawings indicate a 120VAC circuit in a general area labeled for security or access control use, the intent is for this circuit

to be extended and connected to the security or access control device in that general area in coordination with other trades. Coordinated connection requirements and locations between trades and with Owner's Security vendor prior to installation.

F. Motors and Motor Connections: Motors for driven equipment are specified in Divisions 21, 22, and 23. Provide connections as follows, unless otherwise indicated:

1. Equipment provided with factory installed disconnecting means: Upon installation of motor and associated equipment, Provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.

2. Equipment furnished with factory disconnecting means: Upon installation of motor and associated equipment, install factory furnished disconnecting means and provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.

3. Equipment not furnished with factory installed disconnecting means: Provide disconnect switch required in accordance with NFPA 70 or as indicated on the Drawings. Provide the electrical installation in accordance with approved wiring diagrams and manufacturer's written instructions.

G. Owner Furnished Equipment: Power Connections and Control wiring required for Owner Furnished Equipment may not be shown on the Drawings. This wiring shall be provided. Coordinated connection requirements and locations with Owner.

1. Request all rough-in documentation required for proper installation of the electrical work in ample time to permit preparation of the installation drawings.

3.10 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

B. Apply putty pads to boxes located in fire-rated wall assemblies in which a horizontal distance of greater than 24" between boxes is not maintained. Putty pad materials and installation requirements are specified in Division 09 Section "Gypsum Board Assemblies."

3.11 FIELD QUALITY CONTROL

A. Conduct tests as part of the Work of this Division. Include the services of qualified personnel as well as all equipment, apparatus, and services required.

B. Conduct tests under conditions free from short circuits and from grounds.

C. Insure insulation resistance prior to test is within the requirements of the latest edition of the NFPA 70.

D. Prior to execution of testing, notify Architect of proposed test procedures and forms.

E. Testing requirements are listed under individual sections of this Division. Sections requiring testing include, but are not limited to the following:

1. Wire and cable insulation, in accordance with Division 26 Section "Low-Voltage Electrical Power Conductions and Cables."

2. Grounding system continuity, in accordance with Division 26 Section "Grounding and Bonding for Electrical Systems."

3. Lighting control devices, in accordance with Division 26 Section "Lighting Control Devices."

4. Receptacle polarity, and ground resistance testing, in accordance with Division 26 Section "Wiring Devices."

5. NETA tests and startup for enclosed switches and circuit breakers, in accordance with Division 26 Section "Enclosed Switches and Circuit Breakers."

6. NETA tests and startup for enclosed controllers, in accordance with Division 26 Section "Enclosed Controllers."

7. lighting tests, in accordance with Division 26 Section "LED Interior Lighting."

8. NETA thermographic survey on all electrical system equipment.

**END OF SECTION**

# SECTION 26 05 19

# LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.

2. Connectors, splices, and terminations rated 600 V and less.

3. Sleeves and sleeve seals for cables.

1.2 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

C. VFC: Variable frequency controller.

1.3 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Product Data: For each type of product indicated. Provide data for conductors and cables including, but not be limited to, the following:

1. Complete physical properties of the conductors and cables.

2. Ampacity for use intended.

3. Allowable stresses and requirements for installations, including bend radii, linear stress, and other pertinent data.

4. Types of connectors for terminations.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical". Include the following:

1. Feeder cable routing plans, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

a. Structural members in the paths of conduit groups with common supports.

b. HVAC, plumbing items, and architectural features in the paths of conduit groups. Denote where systems share common supports.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For conductors and cables, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:

1. Manufacturer's routine maintenance requirements for cables, terminations and all installed components.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For independent agency as defined in Division 26 Section "Common Work Results for Electrical".

1.7 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

## PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Alcan Products Corporation; Alcan Cable Division.

2. Alpha Wire.

3. Belden Inc.

4. Encore Wire Corporation.

5. General Cable Technologies Corporation.

6. Southwire Incorporated.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Shielded Variable Frequency Drive Cable: Shielded Conductor and signal cable with symmetric bare grounds and overall shield to block EMI and RFI interference.

1. Conductor Material: stranded tinned copper

2. Shield: Foil tape and tinned copper braid shield

3. Comply with 2000V UL 1277 Type TC-ER per NEC Article 336 "Power and Control Tray Cable: Type TC"

4. Rated for 90°C wet/dry.

5. Suitable for Class I & II; Division 2 hazardous locations

6. Comply with UL 1685 vertical tray flame test.

7. Comply with IEEE 1202 vertical tray flame test at 70,000 BTU/hour.

8. Comply with CSA FT4

9. Comply with Oil & Sunlight resistant.

10. RoHS compliant and CE approved.

D. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Types THHN-THWN, and SO, as indicated.

E. Multiconductor Cables: Comply with NEMA WC 70/IECA S-95-658; Exterior sheath color coded to differentiate cable voltages and quantity of phase conductors.

1. Health Care Facilities armored cable, Type AC-HCF; Comply with UL 4 and UL 1479; with green grounding conductor(s) in addition to Armor/Bond Wire ground combination; with exterior sheath colored green.

2. Health Care Facilities Metal-clad cable, Type $MC^{AP}$-HCF; Comply with UL 1569 and UL 1063; with green grounding conductor(s) in addition to full size aluminum ground wire/sheath combination that is listed for sheath to act as second ground path; with exterior sheath colored green.

3. Type SO; with green grounding conductor(s).

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. Gardner Bender.

3. Hubbell Power Systems, Inc.

4. Ideal Industries, Inc.

5. Ilsco; a branch of Bardes Corporation.

6. NSi Industries LLC.

7. O-Z/Gedney; a brand of the EGS Electrical Group.

8. 3M; Electrical Markets Division.

9. Tyco Electronics.

10. WAGO Corporation.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 MISCELLANEOUS 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. Refer to Division 26 Section "Identification for Electrical Systems" for color-coding requirements.

2.4 SYSTEM DESCRIPTION

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 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for all feeders, aluminum for feeders where indicated on Drawings. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Provide conductors with minimum temperature ratings of 75 degrees C. For high temperature applications, provide conductors with temperature ratings in accordance with the NFPA 70 for the ambient condition.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders:

1. Copper: Type THHN-THWN, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces:

1. Copper: Type THHN-THWN, single conductors in raceway.

C. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway and Type AC-HCF and Type MCAP-HCF in limited locations where indicated.

1. Type AC-HCF and Type MC$^{AP}$-HCF are acceptable for the following applications.

a. Install cables for lighting fixture whips and for branch circuits concealed in walls and partitions only.

1) Do not install the cable in the vertical web of metal studs.

2) Route cable horizontally using pre-fabricated openings in web of metal stud.

3) Use only single-circuit cable (i.e. two wire plus ground). For devices in the same wall connected to different circuits, install separate single circuit cable for each circuit.

4) Locate junction box and convert to single conductors in rigid raceway within the same room as where the cable enters/exits the wall.

a) For branch power circuits limit length of AC-HCF and MC$^{AP}$-HCF to 30' from the junction box to the wiring device located in the wall. If the circuit continues outside the wall, the circuit must immediately transition to conduit.

b) For branch lighting circuits limit length of AC-HCF and MC$^{AP}$-HCF to 30' from the junction box to the first fixture and from that point only those fixtures above the enclosed space/room shall be served by the HCF circuit.

2. Type AC-HCF and Type MC$^{AP}$-HCF are not acceptable for the following applications; instead provide single conductors in rigid raceway.

a. Homeruns to Panelboard.

b. Branch circuits serving Essential Electrical System (Emergency & Standby) loads; including Life Safety branch, Critical branch, and equipment emergency system.

c. Branch circuits serving HVAC, elevator/escalator, medical and kitchen equipment loads.

d. Within mechanical, electrical or telecommunication equipment rooms.

e. Exposed Branch Circuits within areas that do not have a ceiling (i.e. open to structure).

f. Wet Locations.

D. Connections to Luminaires on Normal System: Armored Cable, Type AC-HCF, maximum of 144 inches (3660 mm).

E. Connections to Luminaires on Essential/Emergency System: Armored Cable, Type AC-HCF, maximum of 144 inches (3660 mm).

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 and 3 Control Circuits; Concealed in Ceilings, Walls or Partitions: Power-limited cable or Type THHN-THWN, in raceway.

I. Class 2 and 3 Control Circuits; Exposed: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Run feeders in continuous lengths, without joints or splices. Where continuous runs are impractical; obtain Engineer's approval for splice locations and application.

B. Make joints in branch circuits only where circuits divide.

C. Do not use gutters of panelboards as raceways, junction boxes, or pull boxes for conductors not terminating in said panelboards.

D. Run conduits for emergency power conductors separate from all other wiring.

E. Make splices and terminations in cables with kits and instructions provided by the kit manufacturer. Each splice shall equal the integrity of the cable electrically and environmentally.

F. Bundling Conductors: Bundle conductors in switchboards, panelboards, cabinets, and the like, using nylon ties made for the purpose. Bundle conductors larger than No. 10 in individual circuits. Smaller conductors may be bundled in larger groups.

G. Install all conductors in raceways, unless otherwise indicated.

H. Sizes:

1. Provide conductors no smaller than No. 12 AWG, except for signal or control circuits.

2. Provide No. 10 AWG conductors for home runs on 120-volt, 20-ampere branch circuits, where the conductor length exceeds 100 lineal feet from panelboard to the first device.

3. Provide No. 10 AWG conductors for home runs on 277-volt, 20-ampere branch circuits, where the conductor length exceeds 200 lineal feet from panelboard to the first device.

4. Provide neutral conductors of the same size as the phase conductor(s) for individual branch circuit homeruns.

5. Run dedicated neutral conductor with each branch circuit. Sharing of neutral conductors in multi-circuit homeruns is not acceptable.

   a. Sharing of neutrals would necessitate the use of multiple-pole or tied branch circuit breakers to allow simultaneous disconnecting of current caring conductors in order to comply with NFPA 70 requirements and therefore is unacceptable.

6. Grouping of Multi-Circuit homeruns: grouping of multiple circuits into shared conduit homeruns is acceptable where they comply with the quantities and sizes listed in Table "A" below and where homeruns meet the following conditions:

   a. Where conductors are THWN/THHN installed in dry location.

   b. Where raceways are installed in ambient conditions less than 30-Deg C (86-Deg F).

   c. Consider neutral conductors as a current carrying conductor in branch circuits which serve receptacles or electronic ballasted luminaries.

TABLE A

| Number of Current Carrying Conductors in single race-way | Conductor Size for 20Ampere Single Pole Cir-cuit | Conduit Size based on EMT |
|---|---|---|
| 2 to 3 | #12 AWG (THHN 75-Deg) or #12 AWG (THHN 90-Deg) | 3/4" EMT |
| 4 to 6 | #12 AWG (THHN 75-Deg) or #12 AWG (THHN 90-Deg) | 3/4" EMT |
| 7 to 9 | #10 AWG (THHN 75-Deg) or | 1" EMT 3/4" EMT |

| | | |
|---|---|---|
| | #12 AWG (THHN 90-Deg) | |
| 10 to 12 | #10 AWG (THHN 90-Deg) | 1.25" EMT |

Notes:

1. Conductor and conduit sizes in table above are based on total conductor lengths under 100 lineal feet for 120-volt (200 lineal feet for 277-volt) from panelboard to the first device, 20-ampere branch circuits. Increase conductor and conduit size in accordance with NFPA 70 for longer lengths.

I. Terminations of multiple branch circuit conductors on a single circuit breaker is not acceptable.

J. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

K. Complete raceway installation between conductor and cable termination points according to Division 26 Section "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

L. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours.

M. Provide Shielded Variable Frequency Drive Cable between VFDs and equipment being served as followed:

1. Cable distance exceeds 50'.

2. Multiple circuits in a single conduit.

N. For VFDs located remote from the equipment it is serving, provide auxiliary connection between disconnect switch and VFD.

O. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

P. Feeders and Branch circuits concealed in concrete are prohibited.

3.4 WIRE PULLING

A. Pull no conductors into conduits until all Work of a nature which may cause injury to conductors is completed.

B. Follow manufacturers' recommendations for regulating temperature conditions of conductors prior to installation.

C. Exercise care in handling and installing cables to avoid damage. Carefully form cables in equipment pull boxes. Form bends in cables larger than the minimum radii shown in the cable manufacturer's published data for minimum bends such that bends will not reduce the cable life.

D. Provide suitable installation equipment to prevent abrasion and cutting of conductors by raceways during the pulling of conductors. Use ropes of polyethylene, nylon or other suitable non-metallic material to pull in feeders. Metallic ropes are prohibited.

E. Attach pulling lines to conductors by means of insulated woven basket grips or by pulling eyes attached directly to conductors. Do not use rope hitches, or bare steel basket grips. All conductors to be installed in a single conduit shall be pulled in simultaneously.

F. Before any wire is pulled into any conduit, thoroughly swab the conduit to remove all foreign material and to permit the wire itself to be pulled into a clean, dry conduit.

G. Use manufacturer-approved pulling compound or lubricant where necessary, of non-conducting type. Compounds used must not deteriorate the conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

H. Do not use cable pulling lubricants on conductors of ungrounded circuits which are electrically monitored by ground detector system, since such lubricant may increase the capacities to ground of these conductors.

3.5 CONNECTIONS

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

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor.

C. Wiring at Outlets: Install conductor at each device, with at least 6 inches (150 mm) of slack.

D. Wiring at lighting control locations: Install a neutral conductor at each switch location controlling line-to-neutral lighting loads.

E. Connectors: Make splices and connections in conductors using approved connectors.

1. Provide lugs and connectors of proper size to match conductor size.

2. Stranded Conductors: Solder-less, bolted pressure or compression connectors.

3. Solid Conductors: Bolted pressure or spring connectors.

4. Motor Lead Pigtails: Crimp lugs with through-bolt fasteners between lugs. Furnish proper sized dies and tools to apply connectors.

5. Lighting Fixture Taps: Electrical spring connectors as specified for solid conductors.

6. Ground Connections: Ground connection materials and installation requirements are specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

F. Provide temperature ratings of connectors and splices to match wire rating.

3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.7 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Apply Sleeve and Sleeve Seal where raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies. Sleeve and Sleeve Seal materials and installation requirements are specified in Division 26 Section "Common Work Results for Electrical."

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.9 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each feeder, and branch circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance conductors, and conductors of No. 2 AWG and larger for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for one minute.

D. Perform continuity test to insure correct cable connection.

E. Test Values

1. Bolt-torque levels shall be in accordance with Table 1.1 thru Table 1.4, unless otherwise specified by the manufacturer.

**Table 1.1** - Bolt Torque for Bus Connection using Cadmium or Zinc Plated Heat-Treated Steel

| Grade | SAE 1 & 2 | SAE 5 | SAE 7 | SAE 8 |
|---|---|---|---|---|
| Minimum Tensile (P.S.I.) | 64K | 105K | 133K | 150K |
| Bolt Diameter (Inches) | Torque (Foot Pounds) | | | |
| 1/4 | 4.0 | 5.6 | 8.0 | 8.4 |
| 5/16 | 7.2 | 11.2 | 15.2 | 17.6 |
| 3/8 | 12.0 | 20.0 | 27.2 | 29.6 |
| 7/16 | 19.2 | 32.0 | 44.0 | 48.0 |
| 1/2 | 29.6 | 48.0 | 68.0 | 73.6 |
| 9/16 | 42.4 | 70.4 | 96.0 | 105.6 |
| 5/8 | 59.2 | 96.0 | 133.6 | 144.0 |
| 3/4 | 96.0 | 160.0 | 224.0 | 236.8 |
| 7/8 | 152.0 | 241.6 | 352.0 | 378.4 |
| 1 | 225.6 | 372.8 | 528.0 | 571.2 |

**Table 1.2** - Bolt Torque for Bus Connection using Silicon Bronze Fasteners [1]

| | Non-Lubricated | Lubricated |
|---|---|---|
| Bolt Diameter (Inches) | Torque (Foot Pounds) | |
| 5/16 | 15.0 | 10.0 |
| 3/8 | 20.0 | 14.0 |
| 1/2 | 40.0 | 25.0 |
| 5/8 | 55.0 | 40.0 |
| 3/4 | 70.0 | 60.0 |

[1] Bronze alloy bolts with minimum tensile strength of 70,000 pounds per square inch.

**Table 1.3** - Bolt Torque for Bus Connection using Aluminum Alloy Fasteners [2]

| | Lubricated |
|---|---|
| Bolt Diameter (Inches) | Torque (Foot Pounds) |
| 5/16 | 8.0 |
| 3/8 | 11.2 |
| 1/2 | 20.0 |
| 5/8 | 32.0 |
| 3/4 | 48.0 |

[2] Aluminum alloy bolts with minimum tensile strength of 55,000 pounds per square inch.

**Table 1.4** - Bolt Torque for Bus Connection using Stainless Steel Fasteners [3]

| | Uncoated |
|---|---|

| Bolt Diameter (Inches) | Torque (Foot Pounds) |
|---|---|
| 5/16 | 14.0 |
| 3/8 | 25.0 |
| 1/2 | 45.0 |
| 5/8 | 60.0 |
| 3/4 | 90.0 |

[3] Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy. Belleville washers: 302 alloy.

a. Minimum insulation-resistance values shall be not less than 50 megohms.

b. Investigate deviations between adjacent phases.

2. Infrared Scanning: Perform Thermographic Survey in accordance with NETA ATS, Section 9.0.

a. Initial Infrared Scanning: Within 60 Days after Substantial Completion, perform an infrared scan of each termination of or splice in cables and conductors No. 3 AWG and larger. Open or remove doors and covers so connections are accessible to portable scanner.

b. Instruments, Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

F. Cables will be considered defective if they do not pass tests and inspections.

G. Correct Deficiencies, Retest and Report:

1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and devices as required to bring system into compliance.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prepare a written report to record the following:

a. Procedures used.

b. Results that comply with requirements, identifying conductor, units, and devices checked.

c. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

d. Observations and test results after remedial action.

**END OF SECTION**

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# SECTION 26 05 26

# GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

1.1 SUMMARY

A. NFPA 70 and IEEE C2 include basic grounding requirements for electrical safety. This Section supplements the minimum safety requirements of the Code with requirements for additional grounding and with optional grounding methods and materials for both power and electronic systems.

B. This Section includes methods and materials for grounding and bonding systems and equipment.

1.2 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

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

1.3 INFORMATIONAL SUBMITTALS

A. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:

1. Test wells.

2. Ground rods.

3. Ground rings.

4. Grounding arrangements and connections for separately derived systems.

5. Grounding for sensitive electronic equipment.

B. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:

1. Manufacturer's routine maintenance requirements for cables, terminations and all installed components.

2. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NETA MTS.

   a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.

   b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

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

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with NFPA 70.

D. Comply with NFPA 99.

E. Comply with IEEE C2.

F. Comply with ANSI-J-STD-607-A.

## 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. Burndy; Part of Hubbell Electrical Systems.

2. Dossert; AFL Telecommunications LLC.

3. ERICO International Corporation.

4. Fushi Copperweld Inc.

5. Galvan Industries, Inc.; Electrical Products Division, LLC.

6. Harger Lightning and Grounding.

7. ILSCO.

8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.

9. Robbins Lightning, Inc.

10. Siemens Power Transmission & Distribution, Inc.

2.2 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. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.

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.

6. Main Bonding Jumper: stranded copper conductors sized as indicated on Drawings.

7. Grounding Electrode Conductor: stranded copper conductors sized as indicated on Drawings.

8. Common Grounding Electrode Conductor: stranded copper conductors sized as indicated on Drawings.

2.3 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, long barrel with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.4 GROUNDING BUSBARS

A. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8

inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V, unless otherwise indicated. Length as indicated:

1. Main Electrical Room ground bus length: 20 inches (508 mm).

2. Branch Electrical Room ground bus length: 20 inches (508 mm).

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 5/8 inch (16 mm) diameter by 120 inches (3000 mm, unless otherwise indicated.

## PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Insulated solid or stranded for No. 10 AWG and smaller, insulated stranded for No. 8 AWG and larger, unless otherwise indicated.

1. Bury at least 30 inches below grade.

B. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inch minimum, from wall 12 inches above finished floor or 6 feet (1.8 m) above transformer, unless otherwise indicated.

2. Clean and apply anti-oxidant to the contact area prior to conductor connection.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.

4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location as indicated on the Drawings. The electrode shall be connected to the frame of the generator.

B. Dry-Type Transformers: Install an insulated grounding conductor from the common point of connection of the transformer secondary neutral point and the transformer enclosure to the following:

1. The nearest grounding electrode per NFPA 70, including but not limited to building steel where available.

2. The grounding bus of the common electrode grounding system, located in the electrical equipment room.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

1. Bond to each device, box, and luminaire, unless otherwise indicated.

2. Conduction insulation of the same rating as the phase conductors, for all feeders and branch circuits. Install the grounding conductors in the raceway with related phase and neutral conductors.

3. Where parallel conductors in separate raceways occur, provide a grounding conductor in each raceway that meets requirements of NFPA 70.

B. Enclosures: Install an insulated grounding conductor from grounding bushings to the frame of the enclosure, ground bus, and equipment grounding strap where each occurs. Install grounding bushings on all raceways connecting electrical enclosures constructed of separate enclosure panels, which are not integrally welded together.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including but not limited to air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating 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.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway. Terminate at grounding conductor terminal on isolated ground bus of equipment of the applicable derived system or service, unless otherwise indicated.

3.5 INSTALLATION

A. Provide permanent service neutral and equipment grounding in accordance with NFPA 70 and subject to the following additional requirements.

B. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

C. Connect the service neutral and equipment ground to a common point within the metallic enclosure containing the main service disconnecting means. Equipment grounds and the identified neutral of the wiring system shall not be interconnected beyond this point in the interior wiring system. From the common point of connection of the service neutral and the equipment ground, run in non-magnetic conduit a grounding electrode conductor without joint or splice to the grounding electrode system and connect it with an approved bolted pressure clamp.

D. Ground Rods: Drive rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor a minimum of 30-inches below grade unless otherwise indicated. Make connections without exposing steel or damaging coating, if any.

2. For grounding electrode system, install at least two rods spaced at least 6 feet (1.8 m) from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

4. Where expansion joints or telescoping joints occur, provide bonding jumpers.

F. 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 within 5' of point of entrance, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. 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.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

H. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG or a minimum of 20 feet exothermic weld to rebar.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

## 3.6 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components as specified in Division 26 Section "Identification for Electrical Systems."

## 3.7 CONNECTIONS

A. Ground Connections: Provide ground clamps or connectors of a suitable type for ground applications.

B. Ground Bars: Irreversible bolted connector.

## 3.8 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Make tests at ground rods before any conductors are connected.

   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

   b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

1. Report measured ground resistances that exceed the following values:

   a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

   b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.

   c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

   d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

   e. Substations and Pad-Mounted Equipment: 5 ohms.

E. Correct Deficiencies, Retest and Report:

1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and rods as required to bring system into compliance.

2. Prepare a written report to record the following:

   a. Procedures used.

   b. Results that comply with requirements, identifying components checked.

   c. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

   d. Observations and test results after remedial action.

**END OF SECTION**

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# SECTION 26 05 29

# HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

2. Construction requirements for concrete bases.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. RAC: Rigid aluminum conduit.

E. RMC: Rigid metal conduit.

F. RNC: Rigid nonmetallic conduit.

G. RSC: Rigid Steel conduit.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, using performance requirements and design criteria indicated.

1. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

1.4 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 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

## 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.

c. ERICO International Corporation.

d. GS Metals Corp.

e. Thomas & Betts Corporation.

f. Unistrut; Atkore International.

g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. 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 hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Device Box Mounting Brackets and Stabilizer: Factory-fabricated sheet steel brackets for support of device boxes adjacent to or between studs.

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. Cooper B-Line, Inc.

    b. ERICO International Corporation.

F. Through-Stud Cable and Raceway Support Clips: Factory-fabricated spring steel clip for cables or raceways where run horizontally through metal studs.

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. Cooper B-Line, Inc.

    b. ERICO International Corporation.

G. Roof-mounted Raceway Support Blocking: Factory-fabricated support blocking for use under roof-mounted raceways. Wedge-shaped blocking constructed of 100% recycled UV-resistant Rubber with integral galvanized steel strut to accept raceway support clips.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Cooper B-Line C-Port series components or a comparable product by one of the following:

    a. Cooper B-Line, Inc.

    b. ERICO International Corporation.

H. Tee Bar Grid Box Hanger: Factory-fabricated metal electrical box hanger for supporting boxes at locations between ceiling system t-grid components. Height adjustable for various electrical box depths. Attached to ceiling tee bar with screws or integral clamp for stability. Includes tab for independent support wire attachment.

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. Cooper B-Line, Inc.

    b. ERICO International Corporation.

I. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

J. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

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

    a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

        1) Cooper B-Line, Inc.

        2) Empire Tool and Manufacturing Co., Inc.

        3) Hilti, Inc.

        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

        5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.

6. Hanger Rods: Solid, threaded steel.

## PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NFPA 70, NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except where requirements of this Section are more stringent.

B. Maximum Horizontal and Vertical Support Spacing for Raceway(s): Space supports for EMT, IMC, and RMC as required by NFPA 70.

C. Minimum Hanger Rod Size for Raceway Supports: Minimum rod size shall be 1/4 inch (6 mm) in diameter.

D. Single Raceways or Cables:

1. For Raceways 1-1/4-inch (32mm) and smaller: Install adjustable steel band hanger suspended on threaded rod.

2. For Raceways larger than 1-1/4-inch (30mm): Install trapeze-type supports fabricated with steel slotted support system suspended on threaded rods. Size trapeze members, including the suspension rods, based on the support required for the size, and loaded weight of the conduits.

   a. Secure raceway or cable to support with two-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system suspended on threaded rods, where multiple raceways are run vertically or horizontally at the same elevations. Size trapeze members, including the suspension rods, based on the support required for the number, size, and loaded weight of the conduits. Space them as required for the smallest conduit to be supported. Size so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

G. Corrosive Areas: Provide coated steel slotted support systems for supports installed in corrosive areas. Corrosive areas include, but are not limited to the following:

1. Pools and Pool Equipment Areas.

2. Within 25-feet (7.62-m) of Cooling Towers and Air Cooled Chillers.

3. Dishwashing Machine Areas.

3.2 SUPPORT INSTALLATION

A. Comply with NFPA 70, NECA 1 and NECA 101 for installation requirements except where requirements of this Article are more stringent.

B. Fasten junction, pull and devices boxes securely to the building construction, independent of raceway system.

C. Install Device Box Mounting Brackets supported between two studs where boxes are not located adjacent to stud or where multiple boxes are located between studs.

D. Install Device Box Stabilizer where single box is located adjacent to stud.

E. Install Through-Stud Cable and Raceway Support Clips where cables or raceways run horizontally through metal studs.

F. Install Tee Bar Grid Box Hanger supported between two ceiling grid tee bars where devices boxes are located flush in recessed suspended ceilings.

1. Install at least one independent support rod from box hanger to structure.

G. Install Roof-mounted Raceway Support Blocking where raceways run on across roofing.

1. Coordinate installation of roof supports with items specified in Division 07 Section "Roof Accessories." Provide products compatible with rooftop materials included in the Work.

H. Provide minimum of two lock nuts per threaded support rod except where lock nut tightens against a threaded socket, one locknut may be used.

I. Support raceways at a distance above suspended ceilings to permit removal of ceiling panels and luminaires.

J. Locate raceways so as not to hinder access to mechanical equipment.

K. Do not secure conductors, raceways, or supports to suspended ceiling hanger rods or wires.

L. 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.

M. Mounting and Anchorage of Surface-Mounted or Recessed-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. Where support anchors are required, establish their type and locate in concrete construction before concrete is poured, if possible. Fit each hanger rod with a nut at its upper end, and set nut in a universal concrete insert in the form. Where supported weight exceeds holding strength of a single insert, pass rods through top slot of inserts and interlock with reinforcing steel. Also, where particularly heavy loads are to be supported, suspend hanger rod or rods from a structural angle spanning two or more inserts and securely bolted thereto to distribute the weight.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Expansion anchor fasteners.

5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.

6. To Light Steel: Sheet metal screws.

7. For Surface-Mounted Items 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 structure. Attachment to gypsum wall board is not acceptable as sole support means; slotted-channel rack solidly attached to structure or light-gauge metal framing at both ends is required.

8. For Recessed-Mounted Items in Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices to intermediate light-gauge metal framing members on each side of device or provide slotted-channel racks within hollow wall attached to. Attachment to gypsum wall board is not acceptable as sole support means.

N. Do not support any items (equipment, piping, conduit, etc.) exceeding 2 inches in diameter from the bottom of slabs. Where intermediate supports are required between structural members, use slotted steel channels support systems attached to beams or joists in order to avoid attachment to slabs.

O. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars. Verify reinforcing locations with Structural Engineer. X-Ray existing concrete structures as required.

3.3 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 3 inches larger in all directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

D. All floor mounted equipment shall be provided with concrete base, unless otherwise indicated.

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 (0.05 mm).

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

**END OF SECTION**

# SECTION 26 05 33

# RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes:

1. Metal conduits, tubing, and fittings.

2. Metal wireways and auxiliary gutters.

3. Surface raceways.

4. Boxes, enclosures, and cabinets.

B. Provide raceways and boxes for all the other systems, as specified in other Sections of Divisions 26, 27 and 28.

1.2 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical non-metallic tubing.

C. EPC: Electrical Plastic Conduit

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

E. FMC: Flexible metal conduit.

F. IMC: Intermediate metal conduit.

G. LFMC: Liquidtight flexible metal conduit.

H. LFNC: Liquidtight flexible nonmetallic conduit.

I. NBR: Acrylonitrile-butadiene rubber.

J. RMC: Rigid metal conduit.

K. RSC: Rigid Steel conduit.

1.3 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

C. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical". Include the following:

1. Raceway routing plans, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

a. Proposed cable pull points.

b. Structural members in the paths of conduit groups with common supports.

c. HVAC, plumbing items, and architectural features in the paths of conduit groups. Denote where systems share common supports.

B. Source quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store raceway components indoors to prevent water or other foreign materials from staining or adhering to components. Unpack and dry wet materials before storage.

## PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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. Allied Tube & Conduit.

3. Anamet Electrical, Inc.

4. Electri-Flex Company.

5. FSR Inc.

6. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.

7. Patriot Aluminum Products, LLC.

8. Picoma Industries.

9. Republic Conduit.

10. Robroy Industries.

11. Southwire Company.

12. Thomas & Betts Corporation.

13. Western Tube and Conduit Corporation.

14. Wheatland Tube Company.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. RSC: Comply with ANSI C80.1, UL 6, and NEMA FB 2.10; Galvanized rigid steel, each length with a coupling on one end and thread protector on opposite end. Color-coded from factory, refer to Part 3 "Conduit Color Table."

D. IMC: Comply with ANSI C80.6, UL 1242, and NEMA FB 2.10. Color-coded from factory, refer to Part 3 "Conduit Color Table."

E. Fittings for RSC and IMC: Provide factory made threaded couplings of same material as the conduit.

1. Molded thermoplastic insulating bushing at all boxes and cabinets, with locknuts inside and outside box or cabinet. In wet locations, provide watertight hubs for conduit entry into enclosures.

2. Thermoplastic insulated grounding bushing on all conduits where grounding bushings are required, with locknuts inside and outside the enclosure. In wet locations provide watertight hubs for conduit entry into enclosures.

3. Expansion joints: O-Z/Gedney or acceptable submission, with internal ground and external bonding jumper.

a. Expansion fitting: Type AXB.

b. End type expansion fitting: Type EXE.

c. Deflection fitting: Type DX.

d. Pull box fitting: Type EXPB.

e. Combination expansion/deflection fitting: Type AXDX.

F. Conduit fittings for Hazardous (Classified) Locations: Comply with UL 886.

G. PVC-Coated Steel Conduit: Comply with NEMA RN 1 and ETL PVC-001; PVC-coated RSC or IMC with 0.040 inch, minimum coating thickness. Color-coded from factory, refer to Part 3 "Conduit Color Table."

H. Coating for fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

I. EMT: ANSI C80.3 and UL 797. Color-coded from factory, refer to Part 3 "Conduit Color Table."

J. Fittings for EMT:

1. Steel, set-screw couplings.

2. Steel, set-screw insulated throat box connectors with molded thermoplastic insulating bushing at all boxes and cabinets, with locknuts inside box or cabinet.

3. Steel, set-screw insulated throat box connectors with thermoplastic insulated grounding bushing on all tubing where grounding bushings are required.

4. Expansion joints: O-Z/Gedney, type TX or acceptable submission, with internal ground and external bonding jumper.

5. Insulated throat material for fittings to be of a color that is easily distinguishable; clear thermoplastic throats are not acceptable.

K. FMC: Comply with UL 1; Zinc-coated steel. Color-coded from factory, refer to Part 3 "Conduit Color Table."

L. LFMC: Comply with UL 360; Flexible steel conduit with flame retardant PVC jacket and copper grounding strand. Color-coded from factory, refer to Part 3 "Conduit Color Table."

M. Fittings for FMC and LFMC: Comply with NEMA FB 1 and UL 514B.

1. Adapters at connections between flexible and rigid conduit.

2. Thermoplastic insulated throat, steel connectors at box or cabinet terminations, with locknuts inside box or cabinet.

3. Insulated throat material for fittings to be of a color that is easily distinguishable; clear thermoplastic throats are not acceptable.

N. 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.

O. Wire Support Bushings: Provide for vertical runs as required by the NFPA 70. Select for the conductor size involved.

1. For conductors NO. 8 AWG and smaller provide galvanized, non-insulating type.

2. For conductors No. 6 AWG and larger provide O-Z/Gedney, Type SR, insulating type.

P. Joint Compound for RSC or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.; a division of Cooper Industries.

2. Hoffman; a brand of Pentair Equipment Protection.

3. Mono-Systems, Inc.

4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, type and sized according to NFPA 70 as required.

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.

C. Comply with UL 870.

D. Fittings and Accessories:

1. 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.

2. Construct wireways with/without knockouts, as required.

3. Provide spring nuts or guards on all screws installed toward the inside to prevent wire insulation damage.

E. Wireway Covers:

1. Hinged type unless access restrictions require screw-cover type.

2. Flanged-and-gasketed as required for NEMA type.

3. Construct cover to close without the use of parts other than the standard lengths, fittings, and connectors.

4. Provide provisions for the cover to be sealed in the closed position with a sealing wire.

F. Finish: Manufacturer's standard enamel finish.

2.3 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers, complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

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. Hubbell Incorporated; Wiring Device-Kellems.

b. MonoSystems, Inc.

c. Panduit Corp.

d. Wiremold / Legrand.

C. Surface raceways used together with couplings, clips, bushings, straps, connectors, connection covers, elbows, boxes, extension boxes, fixture boxes, extension adapters, blank covers and all other required fittings; size to accommodate the conductors to be installed therein in each case.

2.4 BOXES, ENCLOSURES, AND CABINETS

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. Adalet.

2. Cooper Technologies Company.

3. EGS/Appleton Electric.

4. Erickson Electrical Equipment Company.

5. FSR Inc.

6. Hoffman; a brand of Pentair Equipment Protection.

7. Hubbell Incorporated.

8. Kraloy.

9. Milbank Manufacturing Co.

10. MonoSystems, Inc.

11. Oldcastle Enclosure Solutions.

12. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.

13. RACO; Hubbell.

14. Robroy Industries.

15. Spring City Electrical Manufacturing Company.

16. Thomas & Betts Corporation.

17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

F. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Sheet Metal Pull and Junction Boxes: Comply with NEMA OS 1.

1. Construct boxes from code gauge sheet steel no lighter than 14 gauge with overlapped riveted or welded corners and with edges turned to receive trim.

2. Construct covers from same gauge as box with screw fasteners. Sectionalize boxes over 864 square inches.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

J. Gangable boxes are prohibited.

K. 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.

L. Cabinets:

1. Comply with 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 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Above Ground: RSC, or IMC.

2. Within Crawl Spaces: RSC, or IMC.

3. Emergency Feeders: RSC, or IMC.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R, unless otherwise indicated.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.

a. Mechanical rooms.

2. Exposed and Subject to Physical Damage: RSC, or IMC. Includes, but is not limited to, raceways in the following locations:

   a. Loading dock.

   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

3. Conductors over 600 volts: RSC, or IMC.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.

5. Concealed within Masonry Walls: RSC, or IMC.

6. Concealed under Raised Floors: EMT or LFMC.

7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

8. Flexible Connection to Luminaires on Normal System: FMC, maximum of 72 inches (1830 mm).

9. Connection to Luminaires on Essential/Emergency System: RSC, RAC, IMC, or EMT.

10. Damp or Wet Locations: RSC, or IMC.

11. Elevator Pits: RSC, IMC, or LFMC.

12. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

13. Emergency feeders and branch circuits: EMT.

14. Corrosive Locations: PVC-Coated RSC, PVC-Coated Steel Conduit.

C. Conduit Color Table:

1. Color code conduit in accordance with current facility standard. Where no standard exists for color-coding, provide in accordance with Conduit Color Table below.

| Conduit Color Table | |
|---|---|
| Conduit Service | Color Description |
| Building Automation and Controls | Blue |
| Fire Alarm | Red |
| Life Safety Power Branch | Yellow |
| Critical Power Branch | Orange |

| | |
|---|---|
| Equipment Branch | Green |
| Emergency Power Distribution not listed above | Purple |

D. Minimum Raceway Size:

1. Individual Branch Circuits: 3/4-inch(21-mm).

2. For feeder circuits and multiple branch circuits: 3/4-inch

E. Provide minimum 1/2"-inch(16-mm) conduit for controls circuiting.

F. Junction and Pull Boxes: Sheet steel boxes, unless otherwise indicated.

1. Provide boxes no smaller than 4 inches square and 2-1/8 inches deep.

2. Size all junction and pull boxes in accordance with the NFPA 70, unless project conditions dictate use of larger boxes.

3. Boxes in Hazardous Areas: Cast metal boxes with appropriate sealing fittings.

G. Outlet and Device Boxes: Sheet steel boxes, unless otherwise indicated.

1. For Lighting Fixture Outlets: 4 inch square with raised fixture ring.

2. For Wall Switches, Receptacles, and Communication Use: 4 inch square, one-piece. Use boxes with plaster rings in all plastered walls where wall thickness permits. Use boxes 1-1/2 inch deep only in locations where deep boxes cannot be accommodated by construction.

3. Boxes in Hazardous Areas: Cast metal boxes with appropriate sealing fittings.

H. Boxes Used Outdoors or in Damp/Wet Locations: Cast metal boxes with gasketed covers and threaded hubs.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Store conduit in dry locations during construction. Swab conduits out prior to pulling conductors.

C. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel, unless intumescent putty pads are installed according to Division07 Section "Penetration Firestopping."

D. Locate boxes so that cover or plate will not span different building finishes.

E. 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.

F. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

G. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

H. Recessed Boxes in Fire-Rated Partitions: For boxes located on opposite sides of same partition do not install boxes back-to-back; separate boxes with a minimum of 24 inch separation, unless otherwise indicated in the installation requirements specified in Division 07 Section "Penetration Firestopping."

I. Recessed Boxes in partitions around Acoustically-Sensitive Spaces: For boxes located on opposite sides of same partition do not install boxes back-to-back; separate boxes with a minimum of 24 inch separation. Acoustically-Sensitive Spaces include, but are not limited to, the following:

1. Conference Rooms, Meeting rooms and similar spaces.

2. Classrooms, Training Rooms and similar spaces.

3. Interview Rooms, Consultation Rooms and similar spaces.

4. Auditoriums, Lecture Rooms, and similar spaces.

5. Ballrooms, Private Dinning, and similar spaces.

6. Other spaces specifically listed in the Project Acoustic Consultants' recommendation reports or specifications.

J. On concealed conduit systems where boxes are not otherwise accessible, set boxes flush with finished surfaces for access, and provide overlapping covers.

K. Provide boxes where shown and where necessary for the installation and pulling of cables and wires.

L. Install covers on junction boxes and conduit bodies after wiring and connections are completed.

M. Install raceways perpendicular or parallel to building surfaces with boxes set plumb and square. In areas where there are no suspended ceilings, run all conduits parallel and perpendicular to building surface planes.

N. Install conduits to prevent excessive strain or damage to conductors.

O. Run conductors over 48 Volts in raceway, unless otherwise indicated.

P. Raceways shall not be routed directly over high-heat producing equipment, including but not limited to: steam boilers.

Q. Where raceways are installed running parallel with flues, steam pipes, hot-water pipes, and other objects operating at high temperatures, maintain a minimum of 6 inches (150 mm) between raceway and pipe insulation or jacket.

R. Where raceways cross hot water and steam piping, maintain a minimum of 1-inch (25.4-mm) between raceway and pipe insulation or jacket. Install horizontal raceway runs above water and steam piping.

S. Complete raceway installation before starting conductor installation.

T. Support raceways and boxes as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

U. Conceal conduit within finished walls, ceilings, and raised floors, unless otherwise indicated.

V. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

1. Change from ENT to RSC, or IMC before rising above the floor.

W. No feeders or branch circuits are to be installed in any slab, unless otherwise indicated.

X. No branch circuits are to be installed below slab-on-grade, unless otherwise indicated. Exception: On-grade floor boxes, route raceway minimum of 6 inches below slab-on-grade.

Y. Do not install aluminum conduits in contact with concrete.

Z. Install no more than the equivalent of three 90-degree bends and a maximum of 150 feet between pull points in any conduit run except for communications conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

AA. Join RSC and IMC with threaded couplings. Ream conduits after threading and keep each end closed.

BB. Join EMT with the specified type of couplings. At EMT terminations, provide insulated throat, box connectors and locknuts.

CC. Provide insulating bushing at conduit box terminations. Provide bonding clamps where grounding bushings are required.

DD. Secure rigid conduits at cabinets and boxes with galvanized locknuts, both inside and outside.

EE. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

FF. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

GG. Surface Raceways:

1. Install surface raceway with a minimum 2-inchradius control at bend points.

2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

HH. Install raceways to avoid moisture traps. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2. Where an underground service raceway enters a building or structure.

3. In damp or wet locations.

4. Where otherwise required by NFPA 70.

II. Install raceways and cables as to not hinder access to ceiling space through access hatches. Maintain 36" minimum clearance and required clearance to equipment above ceiling access hatches.

JJ. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

KK. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.

b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.

c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.

d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

LL. Flexible Conduit Connections: Comply with NEMA RV 3.

1. Use minimum of 12 inches (305 mm) and a maximum of 72 inches (1830 mm) at final connections to equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

2. Use LFMC in damp or wet locations including mechanical equipment rooms, at motor or equipment locations at or near pumps, and when installed outdoors.

MM. Where raceways do not terminate in a box or cabinet, install thermoplastic insulating bushings on end of raceway to protect future cabling from physical damage.

NN. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

OO. 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.

PP. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

QQ. Install pull wires free of splices 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. Coil and identify each end of each line with plastic tag bearing complete information as to the purpose of the raceway and the location of its other end.

3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Apply Sleeve and Sleeve Seal where raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies. Sleeve and Sleeve Seal materials and installation requirements are specified in Division 26 Section "Common Work Results for Electrical."

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 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 PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.6 CONNECTIONS

A. Ground raceways and boxes according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify raceways and boxes as specified in Division 26 Section "Identification for Electrical Systems".

3.8 SEGREGATION OF WIRING SYSTEMS

A. Segregation of wiring systems shall not be compromised by the use of common pullboxes, wireways, cabinets or any other type of enclosure.

B. The raceway system for each feeder shall be a separate system completely fault isolated from all other raceway systems.

C. The raceway system for the branch circuits of each panelboard shall be a separate system completely fault isolated from all other raceway systems.

D. In systems operating at more than 300 volts between phase conductors, and where different phase conductors are to be run to a common device or outlet box, provide code gauge barrier equal to box gauge between conductors so that two different phase wires will not be in the same compartment.

3.9 CLEANING

A. On completion of raceway installation but before any cable is installed, perform the following:

1. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. On completion of box, enclosure, and cabinet installation but before any cable or wiring devices are installed, inspect interior of boxes and perform the following:

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

**END OF SECTION**

# SECTION 26 05 53

# IDENTIFICATION FOR ELECTRICAL SYSTEMS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Identification for raceways.

2. Identification for conductors and multi-conductor cables.

3. Underground-line warning tape.

4. Warning labels and signs.

5. Instruction signs.

6. Equipment identification labels.

7. Miscellaneous identification products.

B. Related Sections include the following:

1. Division 26 Section "Wiring Devices" for engraved wall plates and wiring device identification requirements.

1.2 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Product Data: For each electrical identification product indicated.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

D. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

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 POWER AND CONTROL RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Color for Raceways Carrying Circuit at 600V or Less:

1. Black letters on an orange field.

2. Legend: Indicate voltage and system or service type, if applicable.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.

2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING."

D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 MULTI-CONDUCTOR CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Colors for Cables Carrying Circuits at 600 V and Less:

1. Black letters on an orange field.

2. Legend: Indicate voltage and system or service type.

C. Colors for Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.

2. Legend: "DANGER HIGH VOLTAGE WIRING."

D. Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing ends of legend label.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Brass or Stainless Steel Wraparound Marker Labels: Cut from 0.014-inch-thick, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or Stainless Steel, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for interior application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for exterior application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR ## INCHES." Verify work space required for specific project conditions with NFPA 70 and replace "##" in previous sentence with appropriate distance.

3. Arc Flash Warning and Instructions: "WARNING – ARC FLASH AND SHOCK HAZARD. WEAR APPROPRIATE PPE. Determine appropriate protective clothing and personal protective equipment (PPE) for the task from NFPA 70E."

4. Provide detailed labeling in accordance with requirements listed in Division 26 Section "Overcurrent Protective Device Coordination Study".

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.

2. Punched or drilled for mechanical fasteners.

3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 BUSSING DIAGRAM NAMEPLATE

A. Preprinted engraved, laminated acrylic or melamine plastics sign. Nominal size, 12 by 12 inches1/8 inch (3.2 mm) thick. Engraved legend with black letters on white face. Image on sign depicting equipment components in single-line diagram format, using symbols and letter designations consistent with final one-line diagram. Produce a concise visual presentation of principal equipment components and connections.

2.7 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Adhesive, Punched, or drilled for screw mounting. Minimum letter height shall be 3/8 inch. Lettering and Background colors as indicated below:

1. Power Circuits:

   a. Normal: Match existing.

   b. Emergency Legally Required Standby or Essential Electrical System prior to ATS: Match existing.

   c. Emergency Optional Standby: Match existing.

   d. Life Safety Branch: Match existing.

   e. Critical Branch: Match existing.

   f. Equipment Emergency System: Match existing.

2. Fire Alarm System: White lettering on Red background.

3. Fire-Suppression Supervisory and Control System: Match existing.

4. Combined Fire Alarm and Security System: Match existing.

5. Security System: Match existing.

6. Mechanical and Electrical Supervisory System: Match existing.

7. Telecommunication System: Match existing.

8. Control Wiring: Match existing.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Conductor Color-Coding Key: Engraved, Laminated Acrylic, Melamine Label, or Decal-Style Label: Adhesive, Punched, or drilled for screw mounting. Minimum letter height shall be 3/8 inch. Key to describe the conductor color coding scheme used in building in accordance with NFPA 70.

2.9 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

   1. Minimum Width: 3/16 inch.

   2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.

   3. Temperature Range: Minus 40 to plus 185 deg F.

   4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F.

4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.

3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F.

5. Color: Black.

D. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.

1. Exterior Ferrous Metal:

a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.

1) Primer: Exterior ferrous-metal primer.

2) Finish Coats: Exterior semigloss alkyd enamel.

2. Exterior Zinc-Coated Metal (except Raceways):

a. Semigloss Alkyd-Enamel Finish: One finish coat(s) over a primer.

1) Primer: Exterior zinc-coated metal primer.

2) Finish Coats: Exterior semigloss alkyd enamel.

3. Interior Ferrous Metal:

a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.

1) Primer: Interior ferrous-metal primer.

2) Finish Coats: Interior semigloss acrylic enamel.

4. Interior Zinc-Coated Metal (except Raceways):

a. Semigloss Acrylic-Enamel Finish: One finish coat(s) over a primer.

1) Primer: Interior zinc-coated metal primer.

2) Finish Coats: Interior semigloss acrylic enamel.

E. 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 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Conductor Color-Coding Key: Install Instructional Label denoting the conductor color-coding scheme on all panelboards, distribution boards, switchboards, switchgear, motor-control center and similar equipment.

H. Conductor Color-Coding for Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied to conductors or for sizes larger than No. 8 AWG, if authorities having jurisdiction permit, field applied.

2. Colors for Grounding Conductors:

a. Equipment Grounding Conductor: Green.

b. Isolated Equipment Grounding Conductor: Green with Yellow Stripe.

3. Colors for 208/120-V Wye Systems:

a. Phase A: Black.

b. Phase B: Red.

c. Phase C: Blue.

d. Grounded Conductor (Neutral): White

4. Colors for 208/120-V and 240/120-V Delta Systems:

a. Phase A: Black.

b. Phase B (High Leg): Orange.

c. Phase C: Blue.

d. Grounded Conductor (Neutral): White

5. Colors for 480/277-V Wye Systems:

a. Phase A: Brown.

b. Phase B: Purple.

c. Phase C: Yellow.

d. Grounded Conductor (Neutral): Gray

6. Colors for 480/277-V Delta Systems:

a. Phase A: Brown.

b. Phase B (High Leg): Orange.

c. Phase C: Yellow.

d. Grounded Conductor (Neutral): Gray

I. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

J. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

K. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

L. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Multi-Conductor Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30A, and 120V to ground: Identify with self-adhesive vinyl label. Install labels at 10-foot (3-m) maximum intervals.

B. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands every 10 lineal feet:

1. Fire Alarm System: Red.

2. Fire-Suppression Supervisory and Control System: Red and yellow.

3. Combined Fire Alarm and Security System: Red and blue.

4. Security System: Blue and yellow.

5. Mechanical and Electrical Supervisory System: Green and blue.

6. Telecommunication System: Green and yellow.

7. Control Wiring: Green and red.

C. Power-Circuit Conductor Identification, 600V or Less: Identify source and circuit number of each ungrounded conductor or set of conductors. For single conductor cables, identify phase in addition to the above.

1. For conductors in pull and junction boxes, device boxes, and within 6-inches (153 mm) of termination use pre-printed marker tape.

2. For conductors in vaults, manholes, hand holes and pull and junction boxes located in damp or wet locations use brass or stainless steel wraparound marker labels.

D. Power-Circuit Conductor Identification, more than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

G. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply baked-enamel warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:

   a. Power transfer switches.

   b. Main-Tie-Main Switchboards

   c. Generator Paralleling Switchgear.

   d. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

3. Arc Flash Warning Labels: Apply label to door or cover at all access point of equipment including, but not limited to, the following:

   a. Disconnect switches.

   b. Electrical substations.

   c. Electrical switchgear and switchboards.

   d. Emergency system boxes and enclosures.

   e. Enclosed circuit breakers.

   f. Meter Sockets and assemblies.

   g. Motor starters.

   h. Motor-control centers.

   i. Panelboards.

   j. Power transfer equipment. (ATS)

   k. Transformers.

l. Uninterruptible power supply equipment.

H. Available Fault Current Field Marking: Apply label to cover of existing and new service equipment enclosure with the date in which the fault current was calculated and the available fault current as determined by the OCPD coordination study. Table 1 below lists a typical example of label format, coordinate project specific requirements with Drawings.

Table 1 (Example Only)

| MAX. AVAILABLE FAULT: XX,XXXA<br>DATE: X/X/XX |
|---|

I. Junction Boxes and Pull Boxes: Identify voltage, source, and circuit number(s) on cover of pull and junction boxes with hand-written legible block lettering using black permanent marking pen.

J. Color Coding of Junction Boxes and Pull Boxes: Identify system on cover of pull and junction boxes using colored enamel spray paint. Where two colors are indicated identify each half of box with colors indicated.

1. Power Circuits:

a. Normal: Match existing.

b. Emergency Legally Required Standby or Essential Electrical System prior to ATS: Match existing.

c. Emergency Optional Standby: Match existing.

d. Life Safety Branch: Match existing.

e. Critical Branch: Match existing.

f. Equipment Emergency System: Match existing.

2. Fire Alarm System: Match existing.

3. Fire-Suppression Supervisory and Control System: Match existing.

4. Combined Fire Alarm and Security System: Match existing.

5. Security System: Match existing.

6. Mechanical and Electrical Supervisory System: Match existing.

7. Telecommunication System: Match existing.

8. Control Wiring: Match existing.

K. Instruction Signs:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

L. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual.

1. Labeling Instructions:

a. Indoor Equipment: 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 3 lines of text or more are required, use label height as required to accommodate 3/8-inch-high letters.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label drilled and attached with corrosion-resistant screws.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor per ANSI A13.1.

d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Distribution Equipment with Overcurrent Protective Devices to be labeled:

a. Provide for each of the following and any other similar equipment furnished under this Division identification as to its given name, voltage, origination of service, branch, and amps rated interrupting. Obtain final room number from Signage and Graphics Package. Table 2 below lists typical examples of label format, coordinate project specific requirements with Drawings:

1) Electrical switchgear and switchboards.

2) Panelboards.

3) Electrical substations.

4) Motor-control centers.

5) Enclosed switches.

6) Enclosed circuit breakers.

Table 2 (Examples Only)

| | | |
|---|---|---|
| *EMERGENCY SYSTEM*<br>*'EMSA'*<br>*480Y/277V*<br>*FED FROM 'GEN-1'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *NORMAL*<br>*'1DPHA'*<br>*480Y/277V*<br>*FED FROM 'MSA'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *LIFE SAFETY BRANCH*<br>*'1LSHA'*<br>*480Y/277V*<br>*FED FROM 'DPLSHA'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* |
| *EQUIPMENT SYSTEM*<br>*'1EQLA'*<br>*208Y/120V*<br>*FED FROM 'T1EQLA'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *CRITICAL BRANCH*<br>*'1CRHA'*<br>*480Y/277V*<br>*FED FROM 'ATS-CR'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *NON-ESSENTIAL*<br>*'1DPCH-N'*<br>*480Y/277V*<br>*FED FROM 'ATS-N'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* |
| *NORMAL*<br>*'CHP-1'*<br>*480Y/277V*<br>*FED FROM 'MCC-1'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *NORMAL*<br>*'AHU-1'*<br>*480Y/277V*<br>*FED FROM '1DPHA'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* | *EQUIPMENT SYSTEM*<br>*'HWP-1'*<br>*480Y/277V*<br>*FED FROM 'CPEQHA'*<br>*RM #XXXX*<br>*RATED INTERRUPTING:*<br>*XX,XXXA* |

3. Distribution Equipment without Overcurrent Protective Devices to be labeled:

   a. Provide for each of the following and any other similar equipment furnished under this Division identification as to its given name, voltage, origination of service, and branch. Table 3 below lists typical examples of label format, coordinate project specific requirements with Drawings:

      1) Electrical cabinets, and enclosures.

      2) Enclosed Bus Assemblies.

      3) Transformers: Label that includes tag designation for the transformer, feed, and panelboards or equipment supplied by the secondary.

      4) Disconnect switches.

      5) Emergency system boxes and enclosures.

      6) Enclosed controllers.

      7) Variable-speed controllers.

      8) Push-button stations.

      9) Power transfer equipment (ATS) – Label both sources.

      10) Auxiliary Equipment (SPD, Capacitor Banks, etc.).

11) Contactors.

12) Fire-alarm control panel and annunciators.

13) Uninterruptible power supply equipment.

Table 3 (Examples Only)

| *CRITICAL BRANCH* | *EQUIPMENT SYSTEM* | *OPTIONAL STANDBY SYSTEM* |
|---|---|---|
| *'T2CLA'* | *'ATS EQ'* | *'ATS SS'* |
| *75 KVA, 480V to 208Y/120V* | *480Y/277V* | *480Y/277V* |
| *FED FROM '2CHA'* | *FED FROM 'MSA' NORMAL* | *FED FROM 'MSA' NORMAL* |
| *FEEDS '2CRLA'* | *FED FROM 'EMSA'* | *FED FROM 'EMSA'* |
| | *EMERGENCY* | *EMERGENCY* |
| | *FEEDS '1EQHA'* | *FEEDS '1SSHA'* |

4. Other Equipment to be labeled:

   a. Provide for each of the following and any other similar equipment furnished under this Division identification as to its given name.

      1) Access doors and panels for concealed electrical items.

      2) Remote-controlled switches, dimmer modules, and control devices.

      3) Battery inverter units.

      4) Battery racks.

      5) Power-generating units, including remote emergency stop switches.

      6) UPS equipment.

      7) Voice and data cable terminal equipment.

      8) Master clock and program equipment.

      9) Intercommunication and call system master and staff stations.

      10) Television/audio components, racks, and controls.

      11) Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.

      12) Monitoring and control equipment.

      13) Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

5. Provide for each feeder overcurrent protective device in each switchgear, switchboard, distribution panelboard, motor control center, and any other

similar equipment furnished under this Division, identification as to the specific load that it serves.

6. Provide for each 3 phase motor: brass phase rotation tags securely attached to the equipment.

**END OF SECTION**

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# SECTION 26 05 73

# OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for computer-based, fault-current and overcurrent protective device coordination studies and arc flash protection study. Protective devices shall be set based on Engineer's review of submitted results of the protective device coordination study.

1. Coordination of series–rated devices is not permitted.

2. Delegated Design Requirements for Arc Flash Hazard Analysis.

1.2 PERFORMANCE REQUIREMENTS

A. Overcurrent Protective Device Coordination: All overcurrent protective devices proposed for inclusion in the Work shall be selected to be selectively coordinated with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency power to 0.10 seconds.

B. Prior studies created within the last 12 months are prohibited to be utilized as the starting basis for new studies required. All information including short circuit calculations, device settings, one-line information, distances, and other information required shall be taken from field investigations.

C. Delegated Design for Arc Flash Hazard Analysis: Prepare 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. 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.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. 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. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Simultaneous Action Submittals: The following action submittals shall be made in conjunction with the approval process for system protective devices specified in other Division 26 Sections. The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section "Submittal Procedures" to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor's failure to coordinate simultaneous action submittals will not be considered by the Owner. The following submittals shall be in digital form:

1. Coordination-study input data, including completed computer program input data sheets. Provide editable electronic media including all SKM files and breaker TCC's.

2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report; signed, dated, and sealed by a qualified professional engineer.

4. Arc-flash study input data, including completed computer program input data sheets.

5. Arc Flash Hazard Analysis Report; signed, dated, and sealed by a qualified professional engineer.

C. Product Data: For computer software program to be used for studies.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist and Arc-Flash Hazard Analysis Specialist.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399. For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices 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. The following parts from the Protective Device Coordination Study Report:

    a. One-line diagram.

    b. Protective device coordination study.

    c. Time-current coordination curves.

    d. Coordination setting schedules.

2. Power system data.

B. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

C. Operation and Maintenance Procedures: In addition to items specified in Division 01 Section "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 not acceptable.

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.

C. Delegated Design System Study Specialist Qualifications: Comprehensive engineering analysis by a qualified Professional Engineer or personnel trained and employed by the equipment manufacturer in required calculation methodology.

1. Analysis to be performed by a Professional Engineer or personnel trained, employed, and supervised by a registered Professional Engineer.

2. Registered professional engineer shall be a full-time employee of the electrical equipment manufacturer or a professional engineering firm.

3. Registered Professional Engineer shall have a minimum of ten (10) years of experience in performing power system studies.

4. Report shall be signed and sealed by a Professional Engineer with current registration in the state of Missouri.

D. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

E. Comply with IEEE 399 for general study procedures.

F. Comply with IEEE 1584 for performing Arc Flash Hazard Calculations.

## PART 2 - PRODUCTS

2.1 OVERCURRENT PROTECTIVE DEVICES

A. Basis-of-Design Product: The overcurrent protective device (OCPD) types indicated on the Drawings correspond to products produced by Square D; Schneider Electric. Subject to compliance with the requirements, produce Overcurrent Protective Device Coordination Study based on the exact equipment proposed for inclusion in the Work by the basis-of-design manufacturer, or a comparable product by one of the following acceptable manufacturers listed below.

1. Cutler-Hammer, Inc.; Eaton Corporation.

2. General Electric Co.; Electrical Distribution & Protection Div.

3. Siemens Energy & Automation, Inc.

4. Square D; Schneider Electric.

2.2 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by the following:

1. SKM Systems Analysis, Inc.

2.3 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 242 and IEEE 399 for fault-current and overcurrent protective device coordination studies.

B. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard analysis.

C. Analytical features of fault-current-study computer software program shall include "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 coordination by computer-generated, time-current coordination plots.

2.4 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 and generator designations and kVA ratings.

5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

E. Short-Circuit 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.

2.5 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.

2. Cable size and lengths.

3. Transformer kilovolt ampere (kVA) and voltage ratings.

4. Motor and generator 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 above.

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. Phase and Ground Relays:

1) Device tag.

2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.

3) Recommendations on improved relaying systems, if applicable.

b. Circuit Breakers:

1) Adjustable pickups and time delays (long time, short time, ground).

2) Adjustable time-current characteristic.

3) Adjustable instantaneous pickup.

4) Recommendations on improved trip systems, if applicable.

c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.

2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

4. Plot the following listed characteristic curves, as applicable:

   a. Power utility's overcurrent protective device.

   b. Medium-voltage equipment overcurrent relays.

   c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.

   d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.

   e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.

   f. Cables and conductors damage curves.

   g. Ground-fault protective devices.

   h. Motor-starting characteristics and motor damage points.

   i. Generator short-circuit decrement curve and generator damage point.

   j. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.

6. Comments and recommendations for system improvements.

2.6 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 and generator 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. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article above.

F. 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.

G. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.

2. Protective device clearing time.

3. Duration of arc.

4. Arc-flash boundary.

5. Working distance.

6. Incident energy.

7. Hazard risk category.

8. Recommendations for arc-flash energy reduction.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

I. Equipment specific Arc Flash Warning Labels.

2.7 ARC-FLASH WARNING LABELS

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester 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. Flash Hazard Boundary

2. Short Circuit Current Available

3. Shock Hazard when Cover is Removed

4. Limited Approach Boundary

5. Restricted Approach Boundary

6. Prohibited Approach Boundary

7. PPE Requirements, including the following:

a. Hazard Risk Category

b. Required Minimum Arc Rating of PPE in cal/cm^2

c. Clothing Description

8. 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 for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

1. Proceed with coordination study and arc-flash study only after relevant equipment submittals have been assembled, but prior to their submission to the Architect.

a. Coordination study shall accompany submission of relevant equipment submittals.

b. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 POWER SYSTEM DATA

A. Delegated Design System Analyst performing the short-circuit, protective device coordination study, and arc flash hazard analysis shall furnish the Contractor with a list of required data immediately after award of the contract. Contractor shall expedite collection of the data to ensure completion of the study and analysis as required.

B. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

C. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

1. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field.

2. 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.

D. Source combination shall include present and future motors and generators indicated in the documents.

E. If applicable, include fault contribution of existing motors in the study and analysis.

F. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 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. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

a. Circuit breakers and fuses ratings and types.

b. Relays and associated power and current transformer ratings and ratios.

c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, X/R ratios, taps measured in per cent, and phase shift.

d. Generator short-circuit current contribution data, including short-circuit reactance, rated kilovolt amperes, size, rated voltage, and X/R ratio.

e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.

f. Busway ampacity, impedance, lengths, and conductor material.

g. Motor horsepower and code letter designation according to NEMA MG 1.

h. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

i. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

4. 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. Generator thermal-damage curve.

e. Ratings, types, and settings of utility company's overcurrent protective devices.

f. Time-current-characteristic curves of devices.

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, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

## 3.3 FAULT-CURRENT STUDY

A. A short-circuit current ratings indicated in the Contract Documents are based on Fault-Current study prepared by the Engineer during design and are based on available information and anticipated feeder lengths. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system based on proposed feeder

routing. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Electric Utility's supply termination point.
2. Service Entrance Equipment: Existing.
3. Switchgear and switchboard bus.
4. Unit substation primary and secondary terminals.
5. Medium-voltage controller.
6. Motor-control center.
7. Distribution panelboard.
8. Branch circuit panelboard.
9. Standby Generators and Transfer Switches.
10. Enclosed Fused Switch.
11. Enclosed Circuit Breaker.
12. Enclosed Bus Assembly, including at each plug-in unit.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculate short-circuit currents according to IEEE 551.

E. In addition to IEEE 551 short-circuit current calculations, calculate the short-circuit currents at the following:

1. Motor Controllers: Rated greater than or equal to 2hp at 300V or more.
2. Air-Conditioning and Refrigerating Equipment Controllers: Including, but not limited to, equipment supplied from a branch circuit protected at greater than 60A.
3. Elevator Controllers.
4. VFDs – assume impedance of zero.

F. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers, as appropriate for transformers included in the Work:

a. ANSI C57.12.10.

b. ANSI C57.12.22.

c. ANSI C57.12.40.

d. IEEE C57.12.00.

e. IEEE C57.96.

2. Medium-Voltage Circuit Breakers: IEEE C37.010.

3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.

4. Low-Voltage Fuses: IEEE C37.46.

G. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram, including existing Service Entrance equipment.

H. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

3. Ensure that short-circuit withstand ratings are equal to or higher than the calculated ½-cycle symmetrical fault current. Provide specific pass/fail for equipment evaluation:

a. Fail=95% or greater.

b. Marginal= 85% to less than 95%.

c. Contractor to provide next rating size for equipment noted as failed.

d. Include equipment as follows:

1) Electrical Distribution Equipment: Including, but not limited to, switchgear, switchboards, and panel boards.

2) Motor Controllers.

3) Air-Conditioning and Refrigerating Equipment Controllers.

4) Elevator Controllers.

5) Disconnects.

6) VFDs.

4. 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.

5. Notify Engineer, in writing, of any existing circuit protective devices improperly rated for the calculated available fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.

2. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.

b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves 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.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.

b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.

c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.

d. Fuse-current rating and type.

e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate on log-log scale graphs, with no more than five devices indicated on any plot 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:

a. Device tag.

b. Voltage and current ratio for curves.

c. Three-phase and single-phase damage points for each transformer.

d. No damage, melting, and clearing curves for fuses.

e. Transformer inrush points value set to 8.

f. Maximum fault-current cutoff point.

g. Motor starting characteristics, damage points and overload relay.

h. Thermal damage curve for motors larger than 100 HP.

i. Generator short-circuit decrement curve and damage point, and thermal damage curve.

F. Completed data sheets for setting of overcurrent protective devices.

G. Complete Schedule of breaker settings to summarize information contained on data sheets. Sample schedule has been included at the end of this section for preferred format.

3.5 ARC FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system where work could be performed on energized parts including, but not limited to, the following:

1. Disconnect switches.

2. Electrical substations.

3. Electrical switchgear and switchboards.

4. Emergency system boxes and enclosures.

5. Enclosed circuit breakers.

6. Meter Sockets and assemblies.

7. Motor starter.

8. Motor-control centers.

9. Panelboards.

10. Power transfer equipment. (ATS)

11. Transformers.

12. Uninterruptible power supply equipment.

C. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent protection relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

D. Calculate the arc-flash protection boundary and the corresponding incident energy calculations for multiple system scenarios to be compared and the greatest incident energy to be uniquely reported for each equipment location. Calculations to be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions.

1. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off).

2. The maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

E. Incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators to be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible.

F. For each equipment location with a separately enclosed main device, calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

1. When performing incident energy calculations on the line side of a main breaker, the line side and load side contributions must be included in the fault calculation.

G. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device to compute the incident energy for the corresponding location.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash even, a maximum clearing time based on the specific location shall be utilized.

I. Complete Arc Flash report to be used for the preparation of Arc Flash Warning labels for electrical equipment. Refer to Division 26 Section "Identification for Electrical Systems" for requirements of Arc Flash Study and labels.

3.6 Correct Deficiencies, Re-calculate and Report:

A. After Engineer's initial review, correct unsatisfactory conditions and recalculate to demonstrate compliance; resubmit overcurrent protective devices as required to bring system into compliance.

B. Revise and Resubmit report multiple times as necessary to demonstrate compliance with requirements.

3.7 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels as specified in Division 26 Section "Identification for Electrical Systems". Install labels under the direct supervision and control of the Arc-Flash Hazard Study Specialist.

3.8 DEMONSTRATION

A. Engage the Arc-Flash Hazard Study Specialist or a qualified manufacturer's representative to train Owner's management and maintenance personnel of the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels, minimum of four (4) hours. Refer to Division 01 Section "Demonstration and Training."

1. Training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.

2. Include in Project Close-out Documents training notes, outlines, Power Point presentation of training session, and DVD of recorded training session. Also include attendance record of personnel attending the training session.

**END OF SECTION**

**SAMPLE CIRCUIT BREAKER COORDINATION SCHEDULE**

| DEVICE | DEVICE TYPE | LOAD/DEVICE DESCRIPTION | BREAKER MAUNFACTURER | BREAKER TYPE | FRAME (AMPS) | SENSOR (AMPS) | PLUG (AMPS) | LTPU (%) | LTPU (AMPS) | LTD (SETTING) | STPU (SETTING) | STPU (AMPS) | STD (SETTING) | INST (SETTING) | INST (AMPS) | GFPU (SETTING) | GFPU (AMPS) | GFD (SETTING) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PD-MSCPA | SST | MSCPA MAIN | SQUARE D | MASTERPACT NW | 4000 | 4000 | N/A | 1 | 4000 | 2 | 4 | 16000 | 0.1 | 15 | 60000 | C | 720 | 0.2 |
| PD-CPEQ | TM | DIST PANEL CPEQH VIA A | SQUARE D | KI | 250 | 250 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 10 | 2500 | N/A | N/A | N/A |
| PD-CPLS | TM | PANEL CPLSH VIA ATS | SQUARE D | FI | 100 | 100 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | FIXED | FIXED | N/A | N/A | N/A |
| PD-CPH | SST | PANEL CPH | SQUARE D | POWERPACT PJ | 1200 | 400 | N/A | 1 | 400 | 0.5 | 5 | 2000 | 0.1 | 6 | 2400 | A | 120 | 0 |

LEGEND
SST = STATIC TRIP ELECTRONIC CIRCUIT BREAKER
N/A = NOT APPLICABLE
TM = THERMAL MAGNETIC

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# SECTION 26 27 26

# WIRING DEVICES

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Hospital-grade receptacles.
3. Weather-resistant receptacles.
4. Twist-locking receptacles.
5. Solid-state fan speed controls
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Switches and wall-box dimmers.
9. EPO switches.

1.2 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. SPD: Surge Protective Device.

F. UTP: Unshielded twisted pair.

1.3 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Product Data: For each type of product indicated under PART 2 – PRODUCTS.

C. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data," include the following:

1. Manufacturer's routine maintenance requirements for wiring devices and all installed components.

2. Manufacturers' packing label warnings and instruction manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: For independent agency as defined in Division 26 Section "Common Work Results for Electrical".

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

C. Comply with NFPA 99

D. Comply with NFPA 70

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles. Part numbers listed under products paragraphs in Part 2 articles of this section are included to list the manufacturers' product series and they do not designate the color of the device. Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

2. Leviton Mfg. Company Inc. (Leviton).

3. Pass & Seymour/Legrand; (Pass & Seymour).

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors shall not be installed.

2.3 STRAIGHT BLADE RECEPTACLES

A. Hospital-Grade, Convenience Receptacles, Standard Style, 125 V, 20 A:

1. Requirements:

a. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 Supplement SD, and Federal Specification (FS) W-C-596.

b. Description: Hospital Grade receptacles constructed of high-impact resistant thermoplastic. Wide-body design; back and side-wired; Triple wipe, T-slot, one-piece copper alloy contact design; One-piece nickel-plated brass wrap-around type grounding strap, interlocked into the body in at least 4 points; green ground screw and automatic grounding system attached to the strap; Green dot on the face to signify Hospital Grade.

2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL8310 (simplex), HBL8300 (duplex).

b. Leviton; 8310 (simplex), 8300 (duplex).

c. Pass & Seymour; 8301 (simplex), 8300 (duplex).

2.4 GFCI RECEPTACLES

A. Hospital-Grade, GFCI Convenience Receptacles, 125 V, 20 A:

1. Requirements:

a. Comply with NEMA WD 1, NEMA WD 6, UL 498 Supplement SD, UL 943, Class A, and Federal Specification (FS) W-C-596.

b. Feed-through type, nominal sensitivity to earth leakage of 4-6 milliamperes; Meeting 2006 CSA/UL requirements for End of Life Provision and Reverse Line-Load Miswire.

1) Device shall either render itself incapable of delivering power or indicate by visual or audible means that the device can no longer provide ground fault protection.

2) Device shall not allow current to pass through device when miswired.

c. Description: Hospital Grade straight blade receptacle constructed of high-impact resistant thermoplastic. Wide-body design; back and side-wired; Triple wipe, T-slot, one-piece copper alloy contact design; One-piece nickel-platted brass grounding strap, interlocked into the body in at least 4 points; green ground screw and automatic grounding system attached to the strap; Green dot on the face to signify Hospital Grade. LED indicator on face.

2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; GFR8300HxLA.

b. Leviton; N7899-HG.

c. Pass & Seymour; 2095-HG.

B. Industrial-Grade, Tamper-Resistant, Weather Resistant GFCI Convenience Receptacles, 125 V, 20 A:

1. Requirements:

a. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 Supplement SD, UL 943, Class A, and Federal Specification (FS) W-C-596. Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

b. Feed-through type, nominal sensitivity to earth leakage of 4-6 milliamperes; Meeting 2006 CSA/UL requirements for End of Life Provision and Reverse Line-Load Miswire.

1) Device shall either render itself incapable of delivering power or indicate by visual or audible means that the device can no longer provide ground fault protection.

2) Device shall not allow current to pass through device when miswired.

c. Description: Industrial Specification Grade receptacle constructed of a high-impact resistant thermoplastic. Wide-body design; back and side-wired; Triple wipe, T-slot; One-piece steel grounding strap; green ground screw and automatic grounding system attached to the strap.

2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; GFR5362TR.

b. Leviton; WT899.

2.5 PENDANT CORD-CONNECTOR DEVICES

A. General: Matching, locking-type plug and receptacle body connector in NEMA and Non-NEMA configurations as noted on drawings.

1. Requirements:

a. Comply with NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and Federal Specification (FS) W-C-596.

b. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.

c. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell.

b. Leviton.

c. Pass & Seymour.

2.6 CORD AND PLUG SETS

A. General: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Requirements:

a. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

b. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Hubbell.

b. Leviton.

c. Pass & Seymour.

2.7 SWITCHES

A. General Description: All products listed shall meet the following requirements:

1. Comply with NEMA WD 1, UL 20; Rated UL-94, V2 or better. Manufacturer shall test all switches for proper operation prior to shipment, sample testing is not acceptable.

2. Description: Constructed of high-impact arc-resistant thermoplastic; back and side-wired; heavy-gauge copper alloy one-piece arm and silver-cadmium oxide contacts with quiet-action mechanism; heavy-gauge zinc-plated steel-mounting strap with automatic grounding feature. Compatible with fluorescent, tungsten and resistive loads; with a motor load capacity of at least 80% of switch's current rating. Terminal screws shall be brass double-combination: Philips-head, slotted. Mounting screws shall be triple combination: Philips-head, slotted, Robertson.

B. Toggle Switches, 120/277 V, 20 A:

1. Requirements: Comply with Federal Specification (FS) W-S-896; Industrial Specification Grade toggle switch.

2. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL1221 (single pole), HBL1222 (two pole), HBL1223 (three way), HBL1224 (four way).

b. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).

c. Pass & Seymour; PS20AC1 (single pole), PS20AC2 (two pole), PS20AC3 (three way), PS20AC4 (four way).

2.8 FAN SPEED CONTROLS

A. Modular, 120-V:

1. Requirements: Full-wave, solid-state units with integral, quiet on-off switches complying with UL20, and audible frequency and EMI/RFI filters. Comply with UL 1917.

a. Continuously adjustable slider, 5 A.

b. Three-speed adjustable slider, 1.5 A.

2. Products: Subject to compliance with requirements, provide products from one of the following manufacturers:

a. Hubbell.

b. Leviton.

c. Lutron.

d. Novitas.

e. Pass & Seymour.

2.9 DIGITAL TIME WALL SWITCH

A. Requirements: Adjustable time delay up to 2 hours, LCD digital display, Audible or 'Blink' Warning.

B. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Hubbell Building Automation; TD200.

2. Hubbell; DT1277.

3. Leviton; LTBxx.

4. Watt Stopper; TS-400.

2.10 EPO SWITCHES

A. General Description: All products listed shall meet the following requirements:

1. Operators shall be heavy duty type and comply with UL Type 13/NEMA Type 13 and UL Type 6/NEMA Type 6.

2. Contact blocks shall be rated 10 amperes continuous.

B. Available Products: Subject to compliance with requirements, provide the following as indicated on the Drawings:

1. Push button type: Flush mounted, two position, momentary push button, red insert, with one normally open and one normally closed (1NO - 1NC) contact. Provide with a hinged, lockable protective cover guard.

2.11 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Requirements:

a. Plate-Securing Screws:

1) Metal with head color to match plate finish.

b. Material for Finished Areas: Smooth, high-impact thermoplastic (nylon).

c. Material for Utility Areas: Smooth, high-impact thermoplastic (nylon); exposed devices shall be galvanized steel.

d. Material for Unfinished Areas: Smooth, high-impact thermoplastic (nylon); exposed devices shall be galvanized steel.

e. Material for Damp Locations: Thermoplastic (nylon) with spring-loaded lift cover, and listed and labeled for use in "wet locations."

f. Material for Multi-device wall plates over 4-gang: Steel with baked enamel factory painted to match plastic devices.

2. Products: Subject to compliance with requirements, provide plate from same manufacturer as device.

B. Wet-Location, Weatherproof Cover Plates:

1. Requirements: NEMA 250, complying with type 3R weather-resistant, extra-duty, while-in-use cover and base with lockable cover; non-removable gasket between the mounting plate/base and cover; stainless steel hinges and mounting hardware.

2. Products: Subject to compliance with requirements, provide one of the following:

a. Cover and Base Material: UV resistant polycarbonate.

1) Leviton;

a) Horizontal Mount: Clear, 5981-UCL.

b) Vertical Mount: Clear, 5981-UCL.

2) Pass & Seymour; Horizontal or Vertical Mount: Frosted, WIUC10FRED.

3) TayMac Corporation; a Division of Hubbell Incorporated;

a) Horizontal or Vertical Mount: Clear, MM420C.

2.12 FINISHES

A. Color: Wiring device catalog numbers in Section Text above do not designate device color. The wiring devices and associated wall plates shall conform to the colors listed in Table 1 below or as otherwise required by NFPA 70. Final color selections for all devices and wall plates shall be submitted to and approved by the Architect.

1. * Indicates: Provide Orange Triangle on device to Indicate Isolated Ground Receptacle

2. ** Indicates: Engrave (Metal) or Hot Stamp (Thermoplastic) as indicated in "Identification" paragraphs of PART 3 - Execution section.

Table 1

| **Connected to Normal Power in Utility Areas** | **Device** | **Wall Plate** | **Lettering**** |
|---|---|---|---|
| Standard NEMA 5-20R Receptacles | White | Metal | Black |
| GFCI NEMA 5-20R Receptacles | White | Metal | Black |
| Switches | White | Metal | Black |
| Switchbox-Mounted Occupancy Sensors | White | Metal | Black |

| **Connected to Emerg. Pwr. in Utility Areas** | **Device** | **Wall Plate** | **Lettering**** |
|---|---|---|---|
| Standard NEMA 5-20R Receptacles | Red | Metal | Red |
| GFCI NEMA 5-20R Receptacles | Red | Metal | Red |
| Switches | Red | Metal | Red |
| Switchbox-Mounted Occupancy Sensors | White | Metal | Red |

## PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following for all indoor applications, unless otherwise indicated:

1. Receptacle Grade: Hospital-Grade

2. Receptacle Style: Standard

3. Switch Style: Toggle

B. Receptacles in Patient Care Areas: Install Hospital Grade devices where device is located within a Patient Care Area as defined by NFPA 70 Article 517 or the Authorities Having Jurisdiction.

C. GFCI Receptacles: Install in locations as indicated but in no case less than those listed below:

1. Where device is located on the exterior of the building, provide with Wet-Location Weatherproof Cover Plate.

2. Where device is located within kitchen.

3. Where device is located within a garage.

4. Where device is located in an elevator pit.

5. Where device is located within 6 feet (2-m) of a lavatory or sink.

3.2 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise indicated.

B. Mounting Heights: Comply with applicable codes and requirements of Authorities Having Jurisdiction. Mount devices as indicated on Drawings, including but not limited to Architectural elevations. Coordinate all above counter receptacles with backsplash to avoid interferences. All dimensions are given to centerline of box above finished floor (AFF), unless otherwise indicated.

C. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. 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.

5. Install wiring devices with appropriate backbox and raceway according to room finish (i.e. flush mounted devices in recessed backboxes with concealed conduit in finished spaces; surface mounted boxes with exposed conduit in unfinished spaces. Refer to Architectural Documents for room finish types.

E. 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. Pigtailing existing conductors is permitted provided the outlet box is large enough.

F. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until substantial completion.

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.

10. Mount Switches or Wall Box Dimmers within 6 inches of door frame, unless otherwise indicated.

11. Install Isolated-Ground devices so as not to bond the ground pole or isolated ground conductor (green/yellow) to the conduit system or equipment ground conductor (green).

12. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical.

G. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up and on horizontally mounted receptacles to the left (i.e. neutral blade at the top).

H. Device Plates and Covers:

1. Do not use oversized or extra-deep plates.

2. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

3. Install weather-proof-while-in-use covers over receptacles in wet, damp and exterior locations.

4. Group adjacent devices under single, multigang wall plates.

I. Dimmers:

1. Install dimmers within terms of their listing.

2. Verify that dimmers used for fan speed control are listed for that application.

3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

3.3 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served on all receptacles. Use Engraved machine printing for Metal and Hot Stamped for Thermoplastic wall plates. All lettering shall be filled on face of plate, lettering color as indicated in the table in Part 2 above.

2. Switches: Identify panelboard and circuit number from which served on All Switches. Use Engraved machine printing for Metal and Hot Stamped for Thermoplastic wall plates. All lettering shall be filled on face of plate, lettering color as indicated in the table in Part 2 above.

3.4 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."

C. For EPO switches, provide 120V power where control power is not provided from equipment.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. 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.

2. Tests for Convenience Receptacles:

   a. Line Voltage: Acceptable range is 105 to 132 V.

   b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.

   c. Ground Impedance: Values of up to 2 ohms are acceptable.

   d. Polarity: test for correct neutral conductor to neutral terminal connection.

   e. Using the test plug, verify that the device and its outlet box are securely mounted.

   f. GFCI Receptacles: Test for tripping values specified in UL 1436 and UL 943.

3. Tests for patient-care areas in Healthcare Facilities: In addition to the test listed above, perform additional field tests and inspections for receptacles in patient care areas. Perform the following tests:

   a. Test straight blade convenience outlets in patient-care areas for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

   b. Test and record the resistance between the ground point of each receptacle and the reference point according to NFPA 99. Resistance level shall be less than 0.1 Ohm.

4. Prepare certified test reports in compliance with NFPA 99 and submit reports in conjunction with field quality control reports required in Division 26 Section "Grounding and Bonding for Electrical Systems". Utilize the Patient Care Area Electrical Testing Form in the Appendix of Division 26 Section "Grounding and Bonding for Electrical Systems" for each patient care area.

5. Test Instruments:

   a. Use instruments that comply with UL 1436.

   b. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Correct Deficiencies and Report:

1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace devices as required to bring system into compliance.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prepare a report that identifies enclosure, units, conductors and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

C. Wiring device will be considered defective if it does not pass tests and inspections.

3.6 CLEANING

A. Clean components according to manufacturer's written instructions.

B. On completion of device box installation but before any wiring devices are installed, inspect interior of boxes and perform the following:

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

C. On completion of wall plate installation, inspect exterior surfaces and perform the following:

1. Remove paint splatters and other spots.

2. Remove all temporary markings and labels.

3. Replace cracked or damaged wall plates.

4. Wipe down all wall plates with approve cleaning agent to remove fingerprints and dust.

**END OF SECTION**

# SECTION 26 28 16

# ENCLOSED SWITCHES AND CIRCUIT BREAKERS

## PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.

2. Nonfusible switches.

3. Bolted-pressure contact switches.

4. High-pressure, butt-type contact switches.

5. Molded-case circuit breakers.

6. Molded-case switches.

7. Enclosures.

1.2 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. GFEP: Ground-fault equipment protection.

C. HD: Heavy duty.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.3 PERFORMANCE REQUIREMENTS

A. Overcurrent Protective Device Coordination: All overcurrent protective devices proposed for inclusion in the Work shall be selected to be selectively coordinated with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency power. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

1.4 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Simultaneous Action Submittals: Enclosed Switches and Circuit Breaker Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section "Overcurrent Protective Device Coordination Study." The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section "Submittal Procedures" to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process. Delay claims arising due to Contractor's failure to coordinate simultaneous action submittals will not be considered by the Owner.

C. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

1. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Time-current curves for each type of overcurrent protection device. Include hardcopy of characteristic curve and TCC Number for use with Power Tools by SKM Systems Analysis, Inc. Indicate available setting points and selectable ranges for each type of adjustable circuit breaker.

D. Shop Drawings: For each enclosed circuit breaker, switch and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details for types other than NEMA 250, Type 1.

b. Bus configuration, current, and voltage ratings.

c. Short-circuit current rating of device and overcurrent protective devices.

2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical" for each location where enclosed switches and circuit breakers are included in the Work.

B. Field quality-control test reports including the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's routine maintenance requirements for enclosed switches and circuit breakers and all installed components.

2. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

3. Time-current curves, including selectable ranges for each type of circuit breaker. Include directory listing each adjustable breaker included in the Work and their final set points.

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. Keys: Six spares for each type of cabinet lock.

2. Touchup Paint: Three 0.5 pint containers of paint matching enclosure finish.

3. Indicating Lights: one for every ten of each type and rating installed. Furnish at least one of each type.

4. Spare Fuses for the following:

a. Potential Transformer Fuses: One for every ten of each type and rating installed. Furnish at least one of each type.

b. Control-Power Fuses: One for every ten of each type and rating installed. Furnish at least one of each type.

c. Fuses for Fusible Power-Circuit Devices: One for every ten of each type and rating installed. Furnish at least three of each type.

d. Fuses and Fusible Devices for Fused Circuit Breakers: One for every ten of each type and rating installed. Furnish at least three of each type.

e. Fuses for Fusible Switches: One for every ten of each type and rating installed. Furnish at least three of each type.

1.8 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories through one source from a single manufacturer, unless otherwise indicated.

1. Breaker Manufacturer: Manufacturer for breakers shall be the same as the manufacturer of other breakers proposed for other portions of the Work.

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 Options: Drawings indicate spatial allocation for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum spatial allocation. Refer to Division 01 Section "Product Requirements."

1.9 DELIVERY, STORAGE, AND HANDLING

A. Prepare equipment for shipment.

1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.

2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

B. Installation Pathway: Coordinate delivery of equipment to allow movement into designated space.

1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

2. Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.

C. Store equipment indoors in clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. Handle equipment components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Comply with requirements defined in Division 26 Section "Common Work Results for Electrical".

B. Field Measurements: Indicate field measurements on Shop Drawings where equipment is proposed for installation in existing spaces.

C. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient Temperature for Circuit Breakers: Not less than 23 deg F and not exceeding 122 deg F.

2. Ambient Temperature for Fused Switches: Not less than minus 22 deg F and not exceeding 122 deg F.

3. Altitude: Not exceeding 6600 feet (2000 m).

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate ratings with utilization equipment nameplate limitations of maximum overcurrent protection device size. Provide enclosed switch or circuit breakers to match utilization equipment requirements.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.

2. General Electric Co.; Consumer and Industrial Division.

3. Square D/Group Schneider.

B. Fusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.

3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

E. Fuses are specified in Division 26 Section "Fuses."

2.3 FUSED POWER CIRCUIT DEVICES

A. Bolted-Pressure or High-Pressure, Butt-Type Contact Switch: UL 977; operating mechanism shall use either a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts or butt-type contacts and a spring-charged mechanism to produce and maintain high-contact pressure when switch is closed.

1. Manufacturers:

a. Eaton Corporation; Cutler-Hammer Products.

b. General Electric Co.; Consumer and Industrial Division.

c. Pringle Electrical Mfg. Co.

d. Square D/Group Schneider.

2. Main Contact Interrupting Capability: Twelve times the switch current rating, minimum.

3. Operating Mechanism: Manual handle operation to close switch stores energy in mechanism for closing and opening.

a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

b. Mechanical Trip: Operation of mechanical lever or push button or another device causes switch to open.

4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

5. Service-Rated Switches: Labeled for use as service equipment.

6. Ground-Fault Relay: Comply with UL 1053. Self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground fault indicator.

   b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.

   c. No-Trip Relay Test: Operation of "no-trip" test control permits ground-fault simulation test without tripping switch.

   d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

7. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

B. Fuses are specified in Division 26 Section "Fuses."

2.4 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.

2. General Electric Co.; Electrical Distribution & Control Division.

3. Square D/Group Schneider.

B. Series–rated devices are not permitted.

C. Molded-Case Circuit Breaker Requirements: UL 489, NEMA AB 3, with interrupting capacity rating to meet available fault current.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Electronic trip-unit circuit breakers: RMS sensing, field-replaceable rating plug, and the following field-adjustable settings:

   a. Long- and short-time pickup levels.

b. Long- and short-time time adjustments.

c. Instantaneous trip.

d. Ground-fault pickup level, time delay, and $I^2t$ response, where indicated.

e. Ground-fault indication alarm, where indicated.

3. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity. Provide as indicated and as required by NFPA 70 for personnel protection.

4. GFEP Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity. Provide as indicated and as required by NFPA 70 for equipment protection.

D. Molded-Case Circuit-Breaker Features: Standard frame sizes, trip ratings, and number of poles. Provide the following features for all included in the Work:

1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material; UL 486 B listed, dual rated and marked for use with copper- or aluminum load-side conductors.

2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

3. Lock-Out Tag Provisions: For installing at least three Lock-Out tags on each circuit breaker to secure the breaker and prevent movement mechanism.

E. Circuit-Breaker Accessories: Standard frame sizes, trip ratings, and number of poles. Provide the following accessories where indicated:

1. Ground-Fault Protection: Provide integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2. Shunt Trip: Set to trip at 55 percent of rated voltage, where indicated.

3. Communication Capability: Communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."

4. Key Interlock Kit: where indicated, provide to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

5. Auxiliary Switch: where indicated, provide two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

6. Remote trip indication and control.

F. Molded-Case Switch Requirements: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

G. Molded-Case Switch Features and Accessories:

1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.

2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.

3. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

4. Key Interlock Kit: Externally mounted to prohibit operation; key shall be removable only when switch is in off position.

2.5 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location as follows, unless otherwise indicated:

1. Indoor Locations: NEMA 250, Type 1**.**

2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

B. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard ANSI Gray enamel over corrosion-resistant treatment or rust-inhibiting primer coat, undersurfaces treated with corrosion-resistant undercoating.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard ANSI Gray enamel over corrosion-resistant treatment or rust-inhibiting primer coat.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces where equipment will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

B. Examine roughing-in of conduits to verify the following:

1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met.

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

3.2 APPLICATION

A. Fused Power Circuit Device Operating Mechanism: Mechanical Trip, except Electrical Trip for switches with ground-fault protection or remotely tripped switches.

B. Molded-Case Circuit Breakers OCPD Type: Thermal-Magnetic Circuit Breakers Electronic Trip-Unit Circuit Breakers, unless otherwise indicated.

3.3 INSTALLATION

A. Install and anchor equipment level on concrete bases, 4-inch nominal thickness. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

B. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

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

D. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated.

F. Anchor floor-mounting switches to concrete base.

G. Mount top of trim 74 inches above finished floor, unless otherwise indicated.

H. Mount plumb and rigid without distortion of box. Mount recessed equipment with fronts uniformly flush with wall finish.

I. Install overcurrent protective devices, controllers, and instrumentation.

J. Install filler plates in unused spaces.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

L. Close unused conduit opening or other unused holes in sides of box with proper mating blank-off plates.

M. Do not use gutters of equipment as raceways for routing feeder conductors from bottom entrance to top-feed lugs or vice versa; an external gutter or conduit shall be used for this purpose.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Enclosure Nameplates: Label each enclosure with engraved Equipment Identification Label as specified in Division 26 Section "Identification for Electrical Systems."

3.5 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."

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each equipment bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

3. Verify switch and relay type and labeling verification.

4. Verify rating of installed fuses.

5. Assist in field testing of equipment including pre-testing and adjusting of equipment and components.

B. Perform the following field tests and inspections and prepare test reports:

1. Inspect equipment installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.

2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.

3. After installing enclosed switches and circuit breakers but before equipment is energized, verify that grounding system at equipment tests to specified value or better.

4. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

a. Section 7.3 for Cables

b. Section 7.5 for Switches

c. Section 7.6 for Circuit Breakers

d. Section 7.11 for Metering and Instrumentation Devices

e. Section 7.13 for Grounding Systems

f. Section 7.14 for Ground-Fault Protection Systems; where applicable.

5. Infrared Scanning: Perform Thermographic Survey in accordance with NETA ATS, Section 9.0.

a. Initial Infrared Scanning: Within 60 Days after Substantial Completion, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors and covers so connections are accessible to portable scanner.

b. Instruments, Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Complete installation and startup checks according to manufacturer's written instructions.

C. Correct Deficiencies, Retest and Report:

1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and devices as required to bring system into compliance.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prepare a report that identifies switchboards, units, conductors and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.7 ADJUSTING

A. Set field-adjustable overcurrent protection device trip characteristics according to settings provided by Engineer-of-Record.

1. Settings will be provided by Engineer-of-Record after the submittal process and review of report required by Division 26 Section "Overcurrent Protective Device Coordination Study." are completed.

3.8 CLEANING

A. Clean components according to manufacturer's written instructions.

B. Prior to installation of front trim and cover plates inspect interior surfaces and perform the following:

1. Remove paint splatters and other spots.

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

C. On completion of front trim and cover installation, inspect exterior surfaces and perform the following:

1. Remove paint splatters and other spots.

2. Remove all temporary markings and labels.

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

4. Repair exposed surfaces to match original finish.

3.9 PROTECTION

A. Temporary Heating: Maintain a clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Apply temporary heating as required.

B. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's management and maintenance personnel to adjust, operate, and maintain enclosed switches and circuit breakers, overcurrent protective devices, instrumentation, and accessories. Refer to Division 01 Section "Demonstration and Training."

**END OF SECTION**

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# SECTION 26 29 13

# 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.

2. Multi-speed controllers.

B. Related Sections include the following:

1. Division 23 Sections for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on constant torque loads in ranges up to 200 hp.

1.2 PERFORMANCE REQUIREMENTS

A. Overcurrent Protective Device Coordination: All overcurrent protective devices proposed for inclusion in the Work shall be selected to be selectively coordinated with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open. This coordination shall be carried through each level of distribution for all branches of normal and emergency power. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

1.3 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 26 Section "Common Work Results for Electrical" for products specified under PART 2 - PRODUCTS.

B. Simultaneous Action Submittals: Enclosed Controller Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section "Overcurrent Protective Device Coordination Study." The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section "Submittal Procedures" to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal

process. Delay claims arising due to Contractor's failure to coordinate simultaneous action submittals will not be considered by the Owner.

C. Product Data: For each type of enclosed controller and related component, include the following:

1. Manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

2. For enclosed controllers with integral overcurrent protection devices, provide rated capacities, features, operating characteristics, furnished specialties, factory settings, accessories and time-current characteristic curves for individual relays and overcurrent protective devices.

   a. Time-current curves for each type of overcurrent protection device. Include hardcopy of characteristic curve and TCC Number for use with Power Tools by SKM Systems Analysis, Inc. Indicate available setting points and selectable ranges for each type of adjustable overcurrent protection device.

3. Power Monitoring Block Diagram: Show devices monitored and interconnections between components specified in this Section. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines. Illustrate coordination among related equipment and power monitoring and control.

D. Shop Drawings: For each enclosed controller and related equipment, include the following:

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:

   a. Enclosure types and details.

   b. Outline and general arrangement drawing showing dimensions and weights of each assembled section.

   c. Short-circuit current rating of equipment assembly.

   d. Feeder entry locations and lug configuration; including size and number of conductors accepted for phase, neutral, and ground conductors.

   e. Nameplate legends.

2. Wiring Diagrams: For each type of enclosed controller and related equipment, include the following:

   a. Power, signal, and control wiring.

b. Schematic control diagrams.

c. Diagrams showing connections of component devices and equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit Coordination Drawings in accordance with Division 26 Section "Common Work Results for Electrical" for each location where enclosed controllers are included in the Work.

B. Field quality-control Test Method and Procedure: List of procedures to be used during functional and operations sequence testing. Method of Procedure should include but not be limited to the following:

1. Tabulation of Testing Equipment and PPE required for tests.

2. Schedule of Shutdowns required.

3. Manufacturer's Recommended Pre-Start Checklists for the following:

a. Overcurrent Protection Devices

b. Metering and Monitoring Equipment

4. Step-by-Step Testing Operations and Criteria for tests listed in Part 3 Paragraph "Field quality-control".

C. Field quality-control test reports including the following:

1. Test results that comply with requirements.

2. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electrical equipment, accessories and components to be included in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's routine maintenance requirements for enclosed controllers and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current curves, including selectable ranges for each type of relay and overcurrent protective device. Include directory listing each adjustable breaker included in the Work and their final set points.

4. Manufacturer's sample system checklists and log sheets.

1.6 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. Spare Fuses: One for every ten of each type and rating installed. Furnish at least one of each type.

2. Indicating Lights: one for every ten of each type and rating installed. Furnish at least one of each type.

3. Touchup Paint: Three 0.5 pint containers of paint matching enclosure finish.

1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: For independent agency as defined in Division 26 Section "Common Work Results for Electrical".

C. Source Limitations: Obtain enclosed controllers, components, and accessories through one source from a single manufacturer, unless otherwise indicated.

D. Product Options: Drawings indicate spatial allocation for enclosed controllers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum spatial allocation. Refer to Division 01 Section "Product Requirements."

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

F. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Prepare equipment for shipment.

1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.

2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

B. Installation Pathway: Coordinate delivery of equipment to allow movement into designated space.

1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

2. Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving equipment into place.

C. Store equipment indoors in clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

D. Handle equipment components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.9 PROJECT CONDITIONS

A. Interruption of Existing Electric Service: Comply with requirements defined in Division 26 Section "Common Work Results for Electrical".

B. Field Measurements: Indicate field measurements on Shop Drawings where equipment is proposed for installation in existing spaces.

1.10 COORDINATION

A. Coordinate layout and installation of enclosed controllers and components with other construction that penetrates floors, ceilings or walls or are supported by them, including but not limited to conduit, piping, other electrical equipment, light fixtures, HVAC equipment, fire-suppression-system components and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

E. 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 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide as base bid. Provide alternate pricing in accordance with Division 01 Section "Alternates" for a comparable product by one of the following:

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

2. Cerus Industrial.

3. Danfoss Inc.; Danfoss Electronic Drives Div.

4. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.

5. Square D; Schneider Electric.

2.2 RATINGS

A. Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system, unless otherwise indicated.

B. Nominal System Voltage: As indicated on the Drawings.

C. Amperage: Amperage as indicated on the Drawings. Provide continuous rating across entire length of main-bus.

D. Short-Circuit Current: Match rating of overcurrent protective device serving enclosed controller assembly.

1. Available Short-Circuit Current: As indicated on the Drawings. Refer to Division 26 Section "Overcurrent Protective Device Coordination Study" for additional requirements.

2.3 MANUFACTURED UNIT FABRICATION

A. Enclosures: Flush- and surface-mounted cabinets, as indicated.

1. Rated for environmental conditions at installed location.

a. Indoor Locations: NEMA 250, Type 1.

b. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

c. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2. Enclosure Finish for Outdoor Units: Factory-applied finish in manufacturer's standard ANSI Gray enamel over corrosion-resistant treatment or rust-inhibiting primer coat, undersurfaces treated with corrosion-resistant undercoating.

3. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard ANSI Gray enamel over corrosion-resistant treatment or rust-inhibiting primer coat.

B. Hand-off-automatic switch: Three-position selector switch.

2.4 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, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 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.

2. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.

1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.

2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.

3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

2.5 MULTI-SPEED ENCLOSED CONTROLLERS

A. Multi-speed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:

1. Compelling relay to ensure that motor will start only at low speed.

2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.

3. Decelerating relay to ensure automatically timed deceleration through each speed.

4. Match multi-speed enclosed controller to motor. Coordinate with motor specified under Division 23 Section "Common Motor Requirements for HVAC Equipment.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Provide the following factory-installed devices within the controller enclosure, unless otherwise indicated:

1. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

2. Control Relays: Auxiliary and adjustable time-delay relays.

3. Elapsed Time Meter: Heavy duty with digital readout in hours.

4. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

5. Auxiliary Contacts: For remote indication or initiation of controller, with spare auxiliary switches and other auxiliary switches required for normal operation. Provide two sets of contacts arranged with two normally open contacts and two normally closed contacts. Sets shall be removable and field-convertible. Wire contacts through secondary disconnect devices to a terminal block in stationary housing.

## PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces where equipment will be installed for compliance with installation tolerances, required clearances, and other conditions affecting performance.

B. Examine roughing-in of conduits to verify the following:

1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met.

D. 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.

1. Coordinate motor starter size with motor supplied under other divisions of these specifications prior to procurement.

2. Supply overloads rated to match motor supplied under other divisions of these specifications prior to procurement.

3.3 INSTALLATION

A. Comply with NECA 230, "Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers (ANSI)" as published by the National Electrical Contractors Association.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosed controllers and components once unit is secured in place.

C. Comply with mounting and support requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

1. For control equipment at walls: Mount on Steel Slotted Support Systems complying with Division 26 Section "Hangers and Supports for Electrical Systems."

2. For controllers not at walls: Provide freestanding Steel Slotted Support Systems complying with Division 26 Section "Hangers and Supports for Electrical Systems."

3. For free-standing floor-mounted controllers: Install and anchor equipment level on concrete bases, 4-inch nominal thickness. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

D. Mount top of trim 74 inches above finished floor, unless otherwise indicated.

E. Mount plumb and rigid without distortion of box. Mount recessed enclosed controllers with fronts uniformly flush with wall finish.

F. Install overcurrent protective devices, controllers, and instrumentation.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

H. Close unused conduit opening or other unused holes in sides of box with proper mating blank-off plates.

I. Do not use gutters of enclosure as raceways for routing feeder conductors from bottom entrance to top-feed lugs or vice versa; an external gutter or conduit shall be used for this purpose.

J. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Equipment Identification Nameplates: Label each enclosed controller with engraved Equipment Identification Label as specified in Division 26 Section "Identification for Electrical Systems."

3.5 CONNECTIONS

A. Tighten electrical connectors, and terminals according to manufacturer's published torque-tightening values.

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

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

D. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

3. Assist in field testing of equipment including pre-testing and adjusting of equipment and components.

B. Perform the following field tests and inspections and prepare test reports:

1. Inspect enclosed controller installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.

2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 26 Sections.

3. After installing enclosed controller but before equipment is energized, verify that grounding system at enclosed controller tests to specified value or better.

4. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

a. Section 7.16.1 Motor Control, Motor Starters

b. Section 7.3 for Cables

c. Section 7.5 for Switches

d. Section 7.6 for Circuit Breakers; where applicable.

e. Section 7.9 for Protective Relays; where applicable.

f. Section 7.10 for Instrument Transformers; where applicable.

g. Section 7.11 for Metering and Instrumentation Devices; where applicable.

h. Section 7.13 for Grounding Systems

5. Infrared Scanning: Perform Thermographic Survey in accordance with NETA ATS, Section 9.0.

a. Initial Infrared Scanning: Within 60 Days after Substantial Completion, perform an infrared scan of each enclosed controller. Open or remove doors and covers so connections are accessible to portable scanner.

b. Instruments, Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

6. Complete installation and startup checks according to manufacturer's written instructions.

C. Correct Deficiencies, Retest and Report:

1. Correct unsatisfactory conditions, and retest to demonstrate compliance; replace conductors, units, and devices as required to bring system into compliance.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Prepare a report that identifies enclosed controller, units, conductors and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.7 ADJUSTING

A. Set field-adjustable overcurrent protection device trip characteristics according to settings provided by Engineer-of-Record.

1. Settings will be provided by Engineer-of-Record after the submittal process and review of report required by Division 26 Section "Overcurrent Protective Device Coordination Study" are completed.

3.8 CLEANING

A. Clean components according to manufacturer's written instructions.

B. Prior to installation of front trim and cover plates inspect interior surfaces and perform the following:

1. Remove paint splatters and other spots.

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

C. On completion of front trim and cover installation, inspect exterior surfaces and perform the following:

1. Remove paint splatters and other spots.

2. Remove all temporary markings and labels.

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

4. Repair exposed surfaces to match original finish.

3.9 PROTECTION

A. Temporary Heating: Maintain a clean dry space with uniform temperature in accordance with manufacturer's requirements to prevent condensation. Apply temporary heating as required.

B. Protect equipment from exposure to dirt, fumes, water, corrosive substances, and physical damage.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's management and maintenance personnel to adjust, operate, and maintain enclosed controllers, overcurrent protective devices, instrumentation, and accessories. Refer to Division 01 Section "Demonstration and Training."

**END OF SECTION**

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