

**PROJECT MANUAL
VOLUME 2**



**University of Kentucky
Renovate/Upgrade UK Healthcare Facilities
Pavilion A-5th Floor**

**AIR HANDLER RFP
UK Project Number 2402.9
September 8, 2020**

Prepared for:

**University of Kentucky
222 Peterson Service Building
Lexington, Kentucky 40506**

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SECTION 20 0513 MOTORS

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 26 2913 - Enclosed Controllers

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 1. Manufacturer
 2. hp, voltage, phase, hertz, rpm
 3. Motor type
 4. Enclosure type
 5. Frame type
 6. Insulation class
 7. NEMA design designation
 8. Service factor
 9. Nominal efficiency at full load
 10. Power factor at full load
 11. Full load amperes
 12. Bearings
 13. Mountings
 14. Dimensions
 15. Weight

1.4 PRODUCT CRITERIA

- A. Motors covered by this Specification shall conform to applicable requirements of NEMA, IEEE, ANSI, and NEC Standards and shall be UL Listed where applicable for service specified.
- B. Motors shall be designed for conditions in which they will be required to perform; i.e., general purpose, splash proof, explosion proof, standard duty, high torque or other special type as required by equipment manufacturers.
- C. Select motors so they do not exceed nameplate rating nor operate into service factor to meet specified duty.
- D. Motors located inside air handling units or exposed located in outdoor or wash down environments shall have totally enclosed fan cooled (TEFC) enclosures.
- E. Motors shall be furnished for starting in accordance with utility requirements and be compatible with starters specified hereinafter or under Electrical sections of Specifications.
 1. Refer to Section 26 2913 - Enclosed Controllers for reduced voltage starting requirements.

PART 2 - PRODUCTS**2.1 MATERIALS**

- A. Materials shall be new and guaranteed for service intended.

2.2 MOTORS

- A. Voltage Ratings
1. Refer to equipment schedules and specification sections for voltages required.
 2. Unless otherwise indicated, motors 1/3 hp and smaller shall be rated 115 V for operation on 120 V, 1 Ph, 60 Hz service.
 3. Unless otherwise indicated, motors 1/2 hp and larger shall be rated:
 - a. 460 V for operation on 480 V, 3 Ph, 60 Hz service.
- B. Motors shall be 4 pole (approximately 1750 rpm) unless otherwise noted.
- C. Single-phase motors shall be furnished with built-in thermal overload protection.
- D. Use NEMA Design B motors, normal starting torque with regreasable ball bearings, and Class B insulation unless specified otherwise or unless manufacturer of equipment on which motor is being used has more stringent requirements.
1. Bearings shall be rated for minimum AFBMA 9, L-10 life of 26,280 hours (belted) and 100,000 hours (direct-coupled) at full-load.
- E. Motors shall be rated continuous duty and have 1.15 service factor unless otherwise noted.
- F. Vibration shall not exceed 0.15" per second, unfiltered peak unless otherwise noted.
- G. Motors (180 frames and larger) shall have provisions for lifting eyes or lugs capable of safety factor of 5.
- H. Full load nominal efficiency of motors 1 hp and larger, except special-purpose motors including 2-speed or multi-speed motors, and rewind motors, shall meet or exceed listed values when tested in accordance with IEEE Standard 112 Method B as defined by NEMA Standard MG 1-12.6C. Efficiency values listed are based on NEMA Premium Efficiency Electric Motors of NEMA MG 1-2011, Table 12-12.

	<u>Open Drip-Proof Motors</u>			<u>Totally Enclosed Fan-Cooled Motors</u>		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
hp	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
1 hp	82.5	85.5	77.0	82.5	85.5	77.0
1.5 hp	86.5	86.5	84.0	87.5	86.5	84.0
2 hp	87.5	86.5	85.5	88.5	86.5	85.5

hp	<u>Open Drip-Proof Motors</u>			<u>Totally Enclosed Fan-Cooled Motors</u>		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
	(6 pole)	(4 pole)	(2 pole)	(6 pole)	(4 pole)	(2 pole)
3 hp	88.5	89.5	85.5	89.5	89.5	86.5
5 hp	89.5	89.5	86.5	89.5	89.5	88.5
7.5 hp	90.2	91.0	88.5	91.0	91.7	89.5
10 hp	91.7	91.7	89.5	91.0	91.7	90.2
15 hp	91.7	93.0	90.2	91.7	92.4	91.0
20 hp	92.4	93.0	91.0	91.7	93.0	91.0
25 hp	93.0	93.6	91.7	93.0	93.6	91.7
30 hp	93.6	94.1	91.7	93.0	93.6	91.7
40 hp	94.1	94.1	92.4	94.1	94.1	92.4
50 hp	94.1	94.5	93.0	94.1	94.5	93.0
60 hp	94.5	95.0	93.6	94.5	95.0	93.6
75 hp	94.5	95.0	93.6	94.5	95.4	93.6
100 hp	95.0	95.4	93.6	95.0	95.4	94.1
125 hp	95.0	95.4	94.1	95.0	95.4	95.0
150 hp	95.4	95.8	94.1	95.8	95.8	95.0
200 hp	95.4	95.8	95.0	95.8	96.2	95.4
250 hp	95.4	95.8	95.0	95.8	96.2	95.8

- I. Single-phase motors for hard starting applications including outdoor applications shall be capacitor start type. Motors for fans and pumps located indoors may be split phase or permanent split-capacitor. Motors shall be equipped with permanently lubricated and sealed ball bearings and shall be selected for quiet operation. Motors 1/8 hp and below may be shaded pole type.
 - 1. Refer to individual equipment section for additional requirements or specific type of motors.
- J. 3 Ph, 2-speed motors shall be one winding, consequent pole, variable torque type and 1 Ph, 2-speed motors shall be capacitor start capacitor run type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install materials in accordance with drawings, approved Shop Drawings and manufacturer's recommendations.

END OF SECTION

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SECTION 20 0529 MECHANICAL SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 20 0700 - Mechanical Systems Insulation
- B. Section 23 0550 - Vibration Isolation (Spring Hangers and Mounts)
- C. Section 23 3114 - Ductwork (for additional duct supports requirements)

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. Provide all supporting devices as specified and as required for proper support of piping, ductwork, equipment, materials and systems.
- B. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.
- C. Support of fire protection pipe shall comply with NFPA 13, Installation of Sprinkler Systems, 2007 Edition.

1.4 SUBMITTALS

- A. Shop Drawings for each piping system for all pipe sizes and all applicable equipment including, but not limited to, the following:
 - 1. Manufacturer's name
 - 2. Model numbers
 - 3. Materials of construction and load ratings (lbs)
 - 4. Schedule of hangers and support devices with pipe support spacing
 - 5. Insulated pipe supports along with application chart or table
 - 6. Insulation protection saddles and weight bearing insulation table
 - 7. Details and calculations for sizing supplementary steel utilized for trapeze or specially designed supports
 - 8. Structural attachments, inserts and concrete anchors. Submit ICC-ES Evaluation Report for each type of anchor.
 - 9. Calculations and drawings for concrete inserts and anchors for each application
 - 10. Drawings showing specific locations of any weld attachments to structure, including weight supported by such attachments
 - 11. Drawings showing specific locations of any suspended loads which exceed 100 lbs within joist chord panel to be attached to open web steel joist structural members. Include weight supported by such attachments. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord.)
 - 12. Equipment mounting devices

13. Pipe guides and anchors
14. All other appropriate data

1.5 DESIGN CRITERIA

- A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME B31 Code for Pressure Piping and MSS Standard Practice SP-58-2009 (Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation), except as supplemented or modified herein.
- B. Support materials shall be steel or stainless steel unless specifically indicated.
- C. Support devices shall have published load ratings.
- D. Unless otherwise indicated, design structural support members and support devices, including couplings, rods, trapeze supports and strut systems, with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
- E. Determine maximum deflection using the following equation.

$$D = \frac{H \text{ or } L}{250}$$

Where D = Max deflection in inches

H = Member height in inches

L = Member length in inches

- F. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.
 1. Corrosive atmospheres include the following locations:
 - a. Exterior locations
 - b. Chemical storage and hazardous waste storage rooms
 - c. Food service/kitchen areas
 - d. Locker/shower rooms
 - e. Utility tunnels
 - f. Cage wash room (dirty and clean)
 - g. Sterilizer/autoclave room
- G. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports. Plastic coated steel supports are acceptable.
- H. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish. Paint type shall be approved by Architect/Engineer.

- I. This Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section 20 0700 - Mechanical Systems Insulation.
- J. In addition to hangers specified in this Section, piping connected to pumps, compressors, and similar rotating or reciprocating equipment shall have vibration isolation hangers or supports for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater.
- K. Piping connected to coils, which are in assembly mounted on vibration isolators, shall have vibration isolation hangers or supports as indicated above. Piping connected to coils, which are in equipment where fan assembly is separately isolated by vibration isolators and flexible connections, does not require additional vibration isolation hangers or supports. Refer to Section 23 0550 - Vibration Isolation for flexible connections, vibration isolators and additional requirements.
- L. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.
- M. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.
- N. Unless otherwise indicated, continuous insert channels are not allowed.
- O. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.
- P. Refer to Structural Documents and ICC-ES Evaluation Report for application of concrete inserts and concrete anchors.
- Q. Lateral braces shall be designed and detailed to apply loads as directly as possible to structural floor slabs, roof decks, or other building lateral elements. Braces shall not be applied to bottom flanges of steel beams or bottom chords of open web steel joists.
- R. Coordinate with General Contractor for any proposed weld attachments to building structure. This may result in use of other welding codes or standards, which may apply to "structural work". Execution of this work may be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.
- S. Top or bottom chords of open web steel joists may be used to support loads, provided total load within panel does not exceed 100 lbs and load is placed concentric to joist. (Panel is length of chord between two adjacent diagonal web members at point of connection to chord).

PART 2 - PRODUCTS

2.1 STRUCTURAL SUPPORTS

- A. Design and provide all supporting steel, not indicated on structural drawings, that is required for installation of mechanical equipment and materials, including angles, channels, beams, connections, etc. to suspend or floor support equipment.

2.2 PIPE HANGERS AND SUPPORTS (METALLIC)

- A. Manufacturers: Anvil (formerly Grinnell), Erico, Tolco, National Pipe Hanger Corporation, or B-Line, equal to Anvil figures listed. Corresponding MSS Type is indicated where applicable.

- B. Hangers/supports for copper pipe where supports directly contact to pipe shall be either plastic, vinyl or epoxy coated.
- C. For insulated pipe supports, refer to Insulated Pipe Supports in Part 3 of this Section.
- D. Clevis and Roller Type Hangers:

<u>System</u>	<u>Pipe Size</u>	<u>Clevis</u>	<u>Roller</u>
Hot Pipes with Insulation (120°F and above)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" to 6"	---	171 (MSS Type-41), 181 (MSS Type-43)
	8" and larger	---	171 (MSS Type-41)
Ambient Bare Pipes (60°F to 119°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 216 (MSS Type-4)	---
Cold Pipes with Insulation (33°F to 59°F)	2" and smaller	65 (MSS Type-1), 260 (MSS Type-1)	---
	2-1/2" and larger	260 (MSS Type-1), 295 (MSS Type-1)	---

- 1. For pipe size 2-1/2" and larger, where there is transverse movement at support points due to thermal expansion/contraction, clevis type hangers similar to Anvil Figure 260 (MSS Type-1) may be used if vertical angle of hanger rod is less than 4°.

E. Flat Surfaces (Trapeze, Rack Type):

- 1. Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Refer to Part 1 for design criteria. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

<u>System</u>	<u>Pipe Size</u>	<u>Straps or Clamps</u>	<u>Rollers</u>	<u>Slides</u>
Hot Pipes with	2" and smaller	243, 244	---	---

Insulation (120°F and above)	2-1/2" and larger	---	171 or 177(MSS Type-41), 271 (MSS Type-45), 274 (MSS Type-46)	257 or 436 with 212 or 432 clamps, Type 1, 2 or 3 for longitudinal movement only and Type 4, 5 or 6 for both longitudinal and transverse movement of piping.
Ambient Bare Steel Pipes (60°F to 119°F)	6" and smaller 8" and larger	B-Line BVT	---	---
Ambient Bare (Copper) pipes (60°F to 119°F)	all sizes	137 (MSS Type-24)	B-Line BVT	
Cold Pipes with Insulation (33°F to 59°F)	10" and smaller 12" and larger	137 (MSS Type-24)	---	---
		432	---	---

2.3 INSULATION PROTECTION SHIELDS

- A. Anvil Fig. 167 (MSS Type-40) constructed of galvanized carbon steel. Per the latest edition of Standard MSS SP-58, select shield to accommodate outer diameter of insulation. Shield length and gauge for insulation compression strength not less than 15 psi, shall be as follows:

<u>Pipe Size</u>	<u>Length</u>	<u>Gauge</u>
1/4" thru 3"	12"	18
4"	12"	16
5" and 6"	18"	16
8" thru 14"	24"	14
16" thru 24"	24"	12

2.4 INSULATION PROTECTION SADDLES

- A. Anvil Fig. 160 Series (MSS Type-39) constructed of carbon steel or alloy steel plate. Select saddles to accommodate insulation thickness specified in Section 20 0700 - Mechanical Systems Insulation.

2.5 WEIGHT BEARING INSULATION INSERTS

- A. Insert thickness shall match pipe insulation thickness. Pipe insulation jackets shall be continuous through sections containing inserts.
- B. Minimum length of inserts shall be 12", or 2" longer than insulation protection shields, whichever is longer. Compressive strength and placement of inserts shall be based on weight of pipe and fluid plus 1.5 safety factor.
- C. Hot Pipes (120°F and above):

1. High-density calcium silicate insulation (Type H) similar to Johns Manville Thermo-12 or cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas. Maximum compression strength for load calculation shall be 90 psi.
- D. Cold Pipes (59°F and below):
1. Cellular glass insulation (Type G) similar to Pittsburgh Corning Foamglas, maximum compressive strength 90 psi, rigid closed cell insulation (Type PP) similar to Trymer Green by ITW, maximum compressive strength for load calculation 31 psi, or expanded polyisocyanurate insulation (Type P) similar to Trymer 2000XP by ITW, maximum compressive strength for load calculation 24 psi.
 2. SNAPP ITZ pre-insulated pipe supports by Mechanical Pipe Shields Mfg or Tru-Balance Insulated Saddles by Buckaroos, Inc. may be used. Pre-insulated pipe supports shall use polyisocyanurate (Trymer 2000 or 4000 or Insul-Phen insulation), with PVC jacket and G90 galvanized steel shield.

2.6 PRE-INSULATED PIPE SUPPORTS

- A. Pipe Shields, Inc., Bergen Pre-Insulated Pipe Supports, Rilco, or Tri-State Industries equal to Pipe Shields models listed
- B. Insulation shall consist of water-resistant calcium silicate of same thickness as adjoining pipe insulation, thermal conductivity not more than 0.38 Btu-in/(hr-ft²·°F) at 75°F mean temperature, minimum density of 13 lb/ft³, and compressive strength not less than 100 psi.
- C. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of 32 lb/ft³ and minimum compressive strength of 600 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.
- D. Use vapor barrier steel jacket around insulation. Insulation jackets shall be galvanized steel conforming to ASTM A-527. Hanger bearing surface shall consist of galvanized sheet metal insulation protection shield or casing.
- E. When recommended by manufacturer, use double layer insulation protection shield at support bearing surface. Insulation shall extend 1" beyond insulation protection shield to maintain vapor barrier integrity.
- F. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes and standards: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.
- G. Load tests shall be made on both supporting materials and configurations. All tests shall be performed by independent testing laboratory. Results of pertinent tests shall be available upon request.
- H. Unless otherwise indicated, pre-insulated pipe supports shall be as indicated in the following schedule. Model numbers are based on Shaw Pipe Shields, Inc.
 1. Pipe supported on hangers: Models A2000, A4000, A9000, D3000 and D3200
 2. Pipe supported on flat surfaces: Models A2000, A4000, A6000, A7000, A7200, and A7400
 3. Pipe supported on pipe rolls: Models A4000, A6000, A8000, A8200, and A8400
 4. Pipe supported on slides: Model "B" Series
 5. A1000, A3000 or A5000 may be used for hot pipes (120°F and above)
- I. Select proper model to conform to pipe service, support style, and support spacing.

- J. Submit chart or table indicating selected model along with pipe sizes, rated loads, support device types and support spacing for each piping system.
- K. Pipe support spacing shall be in accordance with manufacturer's recommendations, but in no case shall exceed maximum spacing indicated under Hanger and Support Spacing in Part 3 of this Section.

2.7 HANGER RODS (METALLIC)

- A. Rods shall conform to the latest MSS Standards except as modified herein. Furnish rods complete with adjusting and lock nuts.
- B. Rods shall have electroplated zinc or hot dip galvanized finish.
- C. Unless otherwise indicated, size rods for individual hangers and trapeze support as indicated in the following schedule. Rod size may be reduced one size for double rod hangers. Total weight of equipment, including valves, fittings, pipe, pipe content and insulation, shall not exceed limits indicated.

<u>Max. Pipe Size</u> <u>With Single Rigid</u> <u>Rod</u>	<u>Rod</u> <u>Diameter (inches)</u>	<u>Max Load (lbs) of Hanger Rod</u> <u>(Not exceeding 650°F Service Temp.)</u>
2"	3/8	730
3"	1/2	1350
5"	5/8	2160
8"	3/4	3230
12"	7/8	4480
18"	1	5900
30"	1-1/4	9500

- D. Threaded rods are not allowed in clean rooms.

2.8 BOLTS, NUTS, STUDS AND WASHERS

- A. ASTM A307, electroplated zinc finish

2.9 ROD ATTACHMENTS

- A. Anvil Fig. 290 (MSS Type-17), galvanized finish

2.10 U-BOLTS

- A. Anvil Fig. 137 (MSS Type-24), galvanized finish

2.11 BEAM CLAMPS

- A. Beam Clamps: Anvil Fig. 133/134 (MSS Type-21), 218 (MSS Type-30), 228 (MSS Type-28 or 29) and 292 (MSS Type-28 or 29)
- B. Top Beam Clamps: Anvil Fig. 227 (MSS Type-25)
- C. C-Clamps: Anvil Fig. 86, 92 or 93 (MSS Type-19 or 23) with set screw and lock nut

2.12 ADJUSTABLE PIPE SADDLE SUPPORTS

- A. Anvil Fig. 264 (MSS Type-38), galvanized finish. Provide Anvil Fig. 63 Type T stanchion with base, galvanized finish, where applicable.

2.13 RISER CLAMPS

- A. Anvil Fig. 261 (MSS Type-8), galvanized finish
- B. Anvil Fig. CT-121, copper plated carbon steel, plastic coated in area at pipe contact, for bare copper tubing
- C. Proset system, proseal plug and fire-fill for sleeved and cored holes.

2.14 CONCRETE INSERTS (WOODEN FORMED CONCRETE)

- A. Anvil Fig. 281 or 282, or Hilti HCI-WF (MSS Type-18), suitable for rod diameter and weight supported.

2.15 CONCRETE INSERTS (METAL DECK FORMED CONCRETE)

- A. Anvil Fig. 284, Tolco No. 109 A, B-Line Fig. B3019, Powers Fasteners "Bang-It", Hilti HCI-MD, or MSCO No. MX34.

2.16 CONCRETE ANCHORS

- A. Manufacturers: Hilti, Powers Fasteners or Red Head
- B. Anchors shall be selected, sized, and detailed by Contractor's structural engineer registered in project's jurisdiction, based on project conditions and in accordance with project building code. Calculations and drawings shall be submitted.
- C. Anchors shall meet ICC Acceptance Criteria, and ICC-ES Evaluation Reports (ESRs) shall specifically list the current applicable codes.
- D. Anchors installed in hardened concrete for purpose of transmitting structural loads from one connected element to another, or for safety related elements such as sprinkler pipes, heavy suspended pipes, and barrier rails shall have ICC-ES report demonstrating anchors have met requirements of AC 193 for mechanical anchors in concrete elements.
- E. Post-installed expansion anchors and undercut anchors installed in hardened concrete shall be qualified for strength design and tested according to ACI 355.2. Designs shall be per the requirements of ACI 318, Appendix D.
- F. Anchors for seismic load application shall be approved by ICC-ES Evaluation Reports to resist seismic loads and selected to meet project seismic design requirements. Refer to Section 20 0549 – Seismic Anchorage and Restraints and Structural drawings.
- G. Anchors shall be zinc plated in accordance with ASTM B633.
- H. Select anchors with load ratings based on cracked concrete conditions.

2.17 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

- A. Manufacturers: Unistrut, B-Line Strut Systems, Anvil-Strut, Power-Strut, Erico, Superstrut, Kindorf, Hilti, and Hydra-Zorb

- B. Channels shall have epoxy paint or electroplated zinc finish.
- C. Channels shall not be lighter than 12 ga.

2.18 PIPE MOUNTING PEDESTALS

- A. Equal to Roof Products & System Corporation consisting of equipment rail, "U" shaped mounting brackets, galvanized threaded rod and cast iron pipe rollers. Rail shall have built-in raised cant to match roof deck insulation.

2.19 EQUIPMENT RAILS

- A. Manufacturers: Roof Products & Systems, ThyCurb, Custom Curb, Inc. or Vent Products equal to Roof Products & Systems Model ER-4 with raised cant style. Mounting rails shall be galvanized steel with integral base plate, continuous welded corner seams, factory installed 2x4 wood nailer and 18 ga galvanized steel counter flashing.
- B. Mounting rail gauge shall be selected to support equipment adequately but shall be not less than 18 ga.
- C. Height shall be as detailed, but not less than 8" above finished roof.
- D. Equipment rails shall span minimum of 2 joists and not cantilever more than 6" where joists are used. Rails shall be level at top with pitch built in when deck slopes 1/4" per foot or greater.

2.20 PIPE ROOF PENETRATION PROTECTIONS

- A. Manufacturers: Roof Products & Systems, ThyCurb or Vent Products equal to Roof Products & Systems "RPS-Pipe Portals" consisting of 12" OD prefabricated roof curb, laminated acrylic coated ABS plastic curb cover with EPDM protective rubber cap and stainless steel clamp.

2.21 PIPE GUIDES

- A. Unless otherwise indicated, guides shall be Pipe Shields, Bergen Pre-Insulated Pipe Supports, or Rilco equal to Pipe Shields "B" Series B3000, B4000, B7000, B8000, selected by load and movement.

2.22 PIPE ANCHORS

- A. Unless otherwise indicated, anchors shall be no-moment type, Shaw Pipe Shields or Rilco equal to Shaw Pipe Shields Insulated Positive Pipe Anchor Model C3000 or C4000 Series, sized to meet anchor forces shown with minimum safety factor of 3.0.
- B. Contractor may fabricate anchors of steel sections suitable for location of installation and for withstanding anchor forces shown with minimum safety factor of 3.0.

2.23 CASEWORK PIPE SUPPORTS

- A. Hinged pipe clamp and Strutcatcher, nylon 12 Grilamid, Clic by Litchfield International.
- B. Vibration isolation pipe clamp, yellow zinc chromate finish, B-Line BVT Series Vibraclamp or Kwik-Clip by B-Line.

2.24 FIXTURE SUPPLY SUPPORT

- A. Galvanized steel stud support bracket, pre-drilled tube support mounting holes, adjustable stud width, Erico TSGB or equal.
- B. UV resistant nylon tube support, rated for 0°F through 130°F, resealable locking mechanism, Erico TPC or equal.
- C. Support bracket and tube support to be from same manufacturer.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.
- B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.
- C. Coordinate hanger and support installation to properly group piping of all trades.
- D. Suspend piping hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.
- E. Piping and ductwork shall be supported independently from other piping or ductwork.
- F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.
- G. Do not support equipment, piping or ductwork from metal roof decking or ceiling grid.
- H. Install adequate supports so as not to over stress either piping or equipment to which piping is connected.
- I. Refer to Section 20 0000 - General Mechanical Requirements for requirements of personnel injury protection guards for supporting devices.

3.2 HANGER AND SUPPORT SPACING

- A. Space pipe hangers and supports for horizontal pipe accordance with the following schedule, with exceptions as indicated herein:
- B. Steel Pipe (Standard Weight and Extra Strong):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/4" and smaller	7'-0"
1-1/2"	9'-0"
2"	10'-0"
2-1/2"	11'-0"
3"	12'-0"
4"	14'-0"

6"	17'-0"
8"	19'-0"
10" and larger	20'-0"

C. Copper Tube (Unless Otherwise Noted):

<u>Pipe Size</u>	<u>Max Spacing</u>
3/4" and smaller	5'-0"
1" to 1-1/4"	6'-0"
1-1/2" to 2-1/2"	8'-0"
3" and larger	10'-0"

D. Copper Tube (Domestic Water, Laboratory Water, Non-potable Water):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/4" and smaller	6'-0"
1-1/2" and larger	10'-0"

E. Copper Tube (Domestic Water, Laboratory Water, Non Potable Water):

<u>Pipe Size</u>	<u>Max Spacing</u>
1-1/2" and smaller	6'-0"
2" and larger	10'-0"

F. Cast Iron Pipe:

1. Maximum hanger and support spacing shall be 10 ft for all pipe sizes. Provide minimum of one hanger per pipe section close to joint on barrel, at each pipe fitting, at change of direction and branch connections.
2. Support Cast Iron No-Hub pipe as recommended in CISPI Publication "Cast Iron Soil Pipe and Fittings Handbook, Chapter IV - Installation of Cast Iron Soil Pipe and Fittings."

G. Maximum spacing shown above may be restricted by strength of attachment to building structure. Submit data with calculations with published load ratings showing attachment to be utilized and maximum spacing allowable for that type of attachment and pipe size.

H. Spacing less than indicated above may be required to conform to building structure design or loading limitations.

I. If pipe size changes between support points, maximum spacing shall be based on the smaller pipe size.

J. If trapeze hangers are used to support multiple services, spacing shall be based on the most restrictive pipe size and material on trapeze hanger.

K. For non-metallic pipe, follow manufacturer's installation recommendations in addition to requirements noted herein.

L. Install supports for vertical piping and anchors as recommended by pipe manufacturer.

- M. Place hangers and supports to meet requirements of Section 23 2116 - Pipe and Pipe Fittings or specific pipe system sections, with regard to pitch for drainage and venting and clearance between services.
- N. Hangers and supports shall bear on outside of insulation when pipes are to be insulated.
- O. Place hangers and supports within 1 ft of each fitting, such as elbows and tees, and at each valve, strainer, and other piping specialty for piping 4" and larger.
- P. Place hanger or support at first elbow upstream of pump inlet and first elbow downstream of pump outlet.

3.3 RISER SUPPORTS

- A. Insulated Piping:
 - 1. Unless otherwise indicated, support vertical piping as indicated below:
 - 2. Support vertical piping at approximately midpoint of riser, secured and anchored to building structure. Provide guides on vertical piping. Use spring hangers at top and bottom of riser and at take offs from riser at each floor. Use spring hangers for minimum 3 hangers away from top and bottom elbows and from each take off at riser.
 - 3. Guide vertical piping 2" and smaller at every floor. Guide 2-1/2" and larger at every other floor. Spring hangers (Type 6) and guides (Type VSG) are specified in Section 23 0550 - Vibration Isolation.
- B. Non-insulated Piping:
 - 1. Unless otherwise indicated, maximum vertical support spacing for ambient bare steel and cast iron pipes shall be 15 ft.
 - 2. Maximum vertical support spacing for other piping including copper tubing and plastic piping shall be 10 ft.
 - 3. Install riser clamps and intermediate supports as required.
 - 4. Rest riser clamps on floor or on pipe sleeve.
 - 5. Non-insulated piping above 120°F such as steam vents shall be supported per insulated piping requirements.

3.4 INSULATION PROTECTION SHIELDS

- A. Install insulation protection shields at support points as specified under Insulated Pipe Supports.
 - 1. Use one shield (bottom) for clevis hanger.
 - 2. Use 2 shields (top and bottom) for roller hanger/support or strap/clamp support. Apply 2 metal straps to hold top and bottom shields onto insulation jacket.

3.5 INSULATION PROTECTION SADDLES

- A. Install saddles at support points as specified under Insulated Pipe Supports. Tack weld saddle to pipe by tacking center of each point of contact. Pack saddle cavity with insulation of same type as specified for piping system.
- B. Where depth of single saddle is less than specified insulation thickness, provide additional saddle tack welded to first saddle to equal insulation thickness.

3.6 INSULATED PIPE SUPPORTS

- A. Install insulated pipe support at each support point of insulated pipe. Provide insulation protection shields except where saddles are used.
- B. Pipe Size 1-1/2" and Smaller:
 - 1. Use insulation protection shields. Pipe insulation specified in Section 20 0700 - Mechanical Systems Insulation shall be continuous through support points.
- C. Pipe Size 2" and Larger:
 - 1. Use pre-insulated pipe supports. Refer to Part 2 for acceptable products.
 - 2. In lieu of pre-insulated pipe supports, field-assembled insulated pipe supports may be used. If used, submit application details including materials, thickness, compression strength, load bearing surfaces, load calculations of support assembly and total pipe weight based on support spacing.
 - 3. Field-assembled insulated pipe supports shall consist of weight bearing insulation inserts and insulation protection shields.
 - 4. Insulation protection saddles may be used in lieu of assembled insulated pipe supports on roller hangers/supports for hot water pipes, low pressure steam and steam condensate pipes.

3.7 PIPE FLOOR SUPPORTS

- A. Unless specifically shown otherwise, use adjustable pipe saddle supports with associated stanchion similar to Anvil Fig. 264/63. Select supports properly for weight and height of pipe stand.

3.8 CONCRETE INSERTS

- A. Concrete insert application, size, loading, and placement shall be this Contractor's responsibility.
- B. Coordinate with General Contractor for placement of inserts before concrete pour. Minimize use of inserts and anchors after concrete pour.

3.9 BEAM CLAMPS

- A. Provide locknut for hanging rod at clamp.
- B. C-clamps are allowed for rod size 3/8" or smaller and only for static loading such as air piping, cold water piping, fire protection piping and, other similar piping and ductwork. C-clamps are not allowed for hot water piping and steam and steam condensate piping, except hot water runouts to terminal heating devices.
- C. C-clamps are not allowed for open web steel joist application.
- D. C-clamps are not allowed for seismic application.

3.10 TRAPEZE SUPPORTS

- A. Construct trapeze supports with struts, angles, or channels and hang them by inserts or welded beam attachments and rods.
- B. Determine trapeze supports spacing by the smallest pipe on trapeze.

3.11 PIPE MOUNTING PEDESTALS

- A. Use for all piping on roof. Install bottom of pedestal flat on roof deck, insulate exterior of pedestal, flash and counter flash.

3.12 EQUIPMENT RAILS

- A. Use for all roof-mounted equipment, which is not curb mounted. Install bottom of equipment rail flat on roof deck. Insulate exterior of equipment rail.
- B. Flashing will be by General Contractor. Provide counter flashing as specified and secure to wood nailer with stainless steel truss head screws.

3.13 CONCRETE ANCHORS

- A. Anchor application, size, and placement shall be this Contractor's responsibility.

3.14 PIPE ROOF PENETRATION PROTECTIONS

- A. Install at points where pipes are penetrating roof. Install as shown and according to manufacturer's installation instructions.

3.15 PIPE GUIDES

- A. Install where shown on drawings.
- B. For manufactured expansion devices, install minimum of 2 pipe guides at each side of manufactured pipe expansion device. Locate first guide no more than 4 pipe diameters from expansion device and second guide at 14 pipe diameters from first guide. Install intermediate guides in accordance with guide spacing data recommended by manufacturer or the following table, whichever is more stringent.

MAXIMUM DISTANCE BETWEEN INTERMEDIATE GUIDES (FT)

<u>Pipe Size</u> <u>(inches)</u>	<u>Pipe Operating Pressure</u>			
	<u>0-50 psig</u>	<u>51-100 psig</u>	<u>101-150 psig</u>	<u>151-200 psig</u>
3	21	19	17	16
4	35	29	25	22
6	57	44	37	32
8	66	52	45	40
10	91	69	58	51
12	107	79	66	58
14	115	85	71	62
16	127	94	78	68

- C. If anchor is located within 4 pipe diameters from expansion joints, guides need not be installed on anchor side.

3.16 PIPE ANCHORS

- A. Install anchors where shown on drawings or in conjunction with expansion joints, loops and swing joints as required to allow proper expansion and contraction of piping without damage to structure, equipment or piping.
- B. Do not anchor piping to concrete block walls, wood, or partition walls.

END OF SECTION

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SECTION 23 0550 VIBRATION ISOLATION**PART 1 - GENERAL****1.1 RELATED WORK**

- A. Section 20 0529 - Mechanical Supporting Devices
- B. Section 23 3314 - Ductwork Specialties (Duct Flexible Connections)

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESIGN CRITERIA

- A. Isolate all motor driven mechanical equipment, unless otherwise noted, from building structure, and from systems that they serve, to prevent equipment vibrations from being transmitted to structure. Unless specifically indicated, follow the latest edition of ASHRAE Application Handbook - Sound and Vibration Control, or manufacturer's recommendations for isolator selection whichever is more stringent.
- B. Select and locate isolators to produce uniform loading and deflection. Use minimum of 4 isolators to support each piece of equipment.
- C. Select vibration isolation devices based on the lowest operating speed of equipment.
- D. Vibration Criteria:
 - 1. All rotating equipment shall operate at speeds less than 80% of their true critical speed. Unless otherwise required, equipment shall be balanced according to recommendations given in the following schedules.
 - 2. Vertical vibration of rotating equipment shall not be greater than levels indicated. Vibration shall be measured on equipment. If equipment has inertia base, allowable vibration level is reduced by ratio of equipment weight alone to equipment weight plus inertia base weight.

<u>Equipment Speed</u> rpm	<u>Maximum Allowable</u> <u>Vibration Displacement</u> Peak-to-Peak (mil)
100 to 200	10
200 to 300	6
300 to 600	4
600 to 1000	3
1000 or 2000	2
over 2000	1

- E. Following field installation, each fan and pump over 25 hp shall be balanced in accordance with the following maximum rms velocity levels:
 - 1. Fans: 0.15 inch/sec
 - 2. Pumps:

0.16 inch/sec	for 30 hp and smaller
0.18 inch/sec	for 40 through 60 hp
0.20 inch/sec	for 75 through 100 hp
0.22 inch/sec	for 125 hp and larger

Allowable field pump vibration values above are based on HI 9.6-2000, Figure 9.6.4.12.

- F. Final in-field balance shall be measured with each fan over 25 hp installed on springs specified for unit. Fans shall be loaded with design static pressure. Measurement shall be carried out in vertical, horizontal and axis planes at impeller shaft bearing location.

1.4 SUBMITTALS

- A. Submit Shop Drawings including, but not limited to, the following:
1. Manufacturer's name
 2. Isolator type and model number
 3. Materials of construction and finish
 4. Dimensional data
 5. Load ratings (lbs)
 6. Isolator free and operating heights
 7. Static deflections
 8. Isolation efficiency based on lowest operating speed
 9. All other appropriate data

1.5 SUPERVISION, INSPECTION AND CERTIFICATION

- A. Vibration isolation manufacturer or qualified representative shall provide supervision to assure correct installation and adjustment of isolators. Upon completion of installation and after system is put into operation, manufacturer or manufacturer's representative, shall make final inspection, adjustment, and submit report to Engineer in writing, certifying correctness of installation and compliance with Specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Materials used shall retain their isolation characteristics for life of equipment served. Elastomeric materials shall comply with ASTM D2240 and shall be oil-resistant industrial grade neoprene.
- B. Isolators shall be treated to resist corrosion.
- C. Isolation devices subject to weather shall have either hot-dip or cold-dip galvanized, cadmium plated, or neoprene coated finish after fabrication and be furnished with limit stops to resist wind.
- D. Vibration isolator springs shall have minimum additional travel to solid equal to 50% of rated deflection.
- E. Ratio of lateral to vertical stiffness of vibration isolators shall not be less than 0.8 or greater than 2.0.
- F. Coordinate selection of devices with isolator and equipment manufacturer.

2.2 MANUFACTURERS

- A. Mason Industries, Amber/Booth Co., Aeroflex-VMC-Korfund. Vibration Eliminator, Vibro-Acoustics, or Kinetics equal to manufacturer's model listed, except flexible pipe connections.
- B. Mason, Metraflex, Proco, Twin City Hose, Engineered Flexible Products (EFP) or Flex-Weld/Keflex for flexible pipe connections.

2.3 TYPE 1 MOUNTS (NEOPRENE PAD)

- A. Mason Type Super W, neoprene waffle pads, 50 durometer. Select number and size of pads as required to accept equipment operating weight evenly.

2.4 TYPE 2 MOUNTS (NEOPRENE PAD)

- A. Mason Type ND or rails Type DNR, double deflection neoprene mounts with cast-in metal inserts for bolting to equipment.
- B. Both surfaces shall be rib molded for skid resistance. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above mountings to compensate for overhang.

2.5 TYPE 3 MOUNTS (UNHOUSED SPRING WITH NEOPRENE)

- A. Mason Type SLF, combination spring and neoprene with rib molded base. Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between baseplate and support.
- B. Mountings shall have leveling bolts rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of compressed height of spring at rated load.

2.6 TYPE 4 MOUNTS (RESTRAINED SPRING WITH NEOPRENE)

- A. Mason Type SLR, combination spring and neoprene with rib molded base similar to Type 3 above, but shall have housing that includes vertical limit stops to prevent spring extension when weight is removed.
- B. Installed and operating heights shall be the same. Maintain minimum clearance of 1/2" around restraining bolts and between housing and spring so as not to interfere with spring action. Limit stops shall be out of contact during normal operations. Use height saving brackets.

2.7 TYPE S BASES (STEEL BASE)

- A. Mason Type WF, structural steel bases, rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. Perimeter members shall be beams with minimum depth equal to 1/10 of longest base span between isolators, but not less than 4". Beam depth need not exceed 14" provided that deflection and misalignment is kept within acceptable limits as determined by manufacturer. Employ height saving brackets in all mounting locations to provide base clearance of at least 1" above floor or housekeeping pad.

2.8 TYPE I BASES (INERTIA BASE)

- A. Mason Type K, or BMK rectangular or T shaped structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. Base depth need not exceed 12" unless specifically

recommended by base manufacturer for mass, rigidity or component alignment. Base depth shall be a minimum of 1/10 of longest base span between isolators, but not less than 6". Forms shall include concrete reinforcement bars welded in place running both ways. Furnish forms with drilled steel members with sleeves welded below holes to receive equipment anchor bolts where anchor bolts fall in concrete locations. Employ height saving brackets in all mounting locations to maintain base clearance of at least 1" above floor or housekeeping pad.

2.9 TYPE 5 HANGERS (SPRING HANGER WITH NEOPRENE)

- A. Mason Type 30N, vibration hangers with steel spring and neoprene element in series. Neoprene element shall be molded with rod isolation bushing that passes through hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit hanger rod to swing through 30° arc before contacting hole and short circuiting spring.
- B. Mason Type DNHS may be used where load rating and specified deflection cannot be accommodated by Type 30N.

2.10 TYPE 6 HANGERS (PRECOMPRESSED SPRING HANGER WITH NEOPRENE)

- A. Mason Type PC30N, vibration hangers similar to Type 5, but precompressed to rated deflection so as to keep piping or equipment at fixed elevation during installation. Design hangers with release mechanism to free spring after installation complete and hanger is subjected to its full load.

2.11 TYPE 7 HANGERS (SPRING HANGER WITH DEFLECTION INDICATOR)

- A. Mason Type HES, steel spring in steel housing including deflection indicator scale. Hangers shall be preset at factory for required load. Select hangers so that actual loads do not exceed rated capacities (lbs).
- B. Submittals shall include isolator rated deflection, required deflection and supporting calculation. Calculations shall be made by registered mechanical or civil engineer demonstrating structural adequacy of hanger and that hanger connections to building and pipe are adequate for live and dead loads encountered.

2.12 TYPE 8 HANGERS (SPRING HANGER WITH NEOPRENE)

- A. Mason Type 30, W30, or PC30 steel spring located in neoprene cup manufactured with grommet to prevent short-circuiting of hanger rod. Neoprene cup to contain steel washer designed to properly distribute load on neoprene and prevent its extrusion. Spring diameters and hanger box lower hole size to be large enough to permit hanger rod to swing through 30° arc before contacting hole and short-circuiting spring. Provide hangers with rod attachments or eyebolts on spring end.

2.13 TYPE AG PIPE ANCHORS/GUIDES

- A. Mason Type ADA all-directional acoustical pipe anchors and Type VSG guides for vertical piping consisting of telescopic arrangement of 2 sizes of steel tubing separated by minimum 1/2" thickness of heavy duty neoprene and neoprene isolation material. Vertical restraints shall prevent vertical travel in either direction. Allowable loads on isolation materials shall not exceed 500 psi and design shall be balanced for equal resistance in any direction.
- B. Submittals shall include supporting calculations by registered mechanical or civil engineer indicating anchor/guide loads and isolator selection.

2.14 TYPE T THRUST RESTRAINTS

- A. Mason Type WB, horizontal thrust restraint consisting of spring element in series with neoprene pad as described for Type 3 mounts with the same deflection as specified for mountings or hangers. Spring element shall be contained within steel frame and designed so it can be preset for thrust at factory and adjusted in field for maximum of 1/4" movement at start and stop. Furnish thrust restraints complete with rods and angle brackets for attachment to both equipment and ductwork or equipment and structure. Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit.

2.15 FLEXIBLE PIPING CONNECTORS

- A. Flexible connectors shall be suitable for pressure, temperature and fluid involved, but not less than 215 psig working pressure at 250°F for 14" and smaller and 150 psi working pressure at 250°F for 16" and larger.
- B. Flexible connectors shall be straight pipe configuration and shall not be used to replace pipe fittings such as elbows.
- C. Unless otherwise specified, minimum live length of flexible connector shall be as follows.

Nominal Pipe Diameter (in)	Minimum Live Length (in)
2-1/2" and smaller	12"
3" and 4"	18"
5" and larger	24"

- D. Water System:
1. Connection to Rotating Equipment:
 - a. Connectors shall consist of Kevlar or Nylon tire cord fabric reinforced with EPDM cover and liner. Solid steel rings or steel wire shall be used within raised face rubber flanged ends to prevent pullout. Furnish connectors with control rods only where recommended by connector manufacturer.
 - b. 2" and Smaller: Threaded connections, single sphere design similar to Mason SAFEFLEX SFU.
 - c. 2-1/2" and Larger: Floating steel flange connections, two sphere design with ductile iron or plated carbon steel reinforcing rings, similar to Mason SAFEFLEX SFDEJ. Single sphere design similar to Mason SAFEFLEX SFEJ, may be used for 14" and larger.
 2. Connection to Non-rotating Equipment Mounted on Vibration Isolators:
 - a. Seamless corrugated bronze or stainless steel flexible connector with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.
- E. Steam and Condensate Including Pumped Condensate System:
1. Seamless corrugated stainless steel flexible connector with braided cover for 2" and smaller with threaded or flanged connections; seamless corrugated stainless steel flexible connector with braided cover for 2-1/2" and larger with flanged connections.
- F. Fuel Oil System:
1. Seamless corrugated bronze flexible connector with braided cover.

G. Refrigerant System:

1. Seamless corrugated bronze flexible connector with bronze wire braided cover and standard copper tube ends for copper piping. Seamless corrugated stainless steel flexible connector with braided cover for steel piping.

H. Compressed Air Systems:

1. Seamless corrugated bronze flexible connector with bronze wire braided cover for copper piping and seamless corrugated stainless steel flexible connector with braided cover for steel piping. Connector ends shall be threaded, soldered, or flanged to match piping system valve ends.

I. Do not provide flexible piping connectors for compressed air piping.

J. Do not provide flexible piping connectors for gas piping.

2.16 PERFORMANCE

- A. Select vibration isolation devices to achieve either minimum 95% isolation efficiency or minimum static deflection and mounting requirements listed below, whichever is greater. Minimum static deflections listed below are not nominal but certifiable minimums with actual installed load. Unless otherwise indicated, apply requirements listed for floor mount for roof-mounted equipment.

<u>Type of Equipment</u>	<u>Ground</u>		<u>Floor Span</u>							
	<u>Supported Slab</u>		<u>Up to 20 ft</u>		<u>20 ft to 30 ft</u>		<u>30 ft to 40 ft</u>		<u>40 ft to 50 ft</u>	
	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)	Type	Min Defl. (in)
<u>Air-Cooled Condensing Units:</u>	-	-	4	0.75	4	1.5	4	2.5	4	3.5

<u>Fan Coil Units, Heat Pump Units and Fan Powered Boxes</u>	Type 5 with minimum deflection of 0.5" for 600 cfm or less and 0.75" for over 600 cfm.
<u>Piping Connected to Rotating or Recipro-Equipment:</u>	<p>Use flexible piping connections, and Type 6 hangers for distance of 100 pipe diameters or 50 ft away from equipment, whichever is greater. Hangers shall have minimum deflection of 0.75" for pipe sizes 3" and smaller, 1.5" for pipe sizes 4" through 6" and 2.5" for pipe sizes 8" and larger. For piping less than 2" in diameter, neoprene or felt pad inserted between pipe or pipe covering and clamp or hanger may be used in lieu of Type 6 hangers.</p> <p>Where piping is floor-supported, above requirements shall apply, but use Type 3 mounts instead of hangers.</p> <p>Flexible piping connection shall not be used for unit heaters and in-line pumps that are supported by connected pipes. Type 6 hangers with 1" minimum deflection shall be applied within one foot of both sides of in-line pump and for distance of 100 pipe diameters or 50 ft away from first hanger at in-line pump, whichever is greater.</p>
<u>Piping 2.5" and Larger Supported from Underside of 1-thru 6 Floors:</u>	Use Type 5 hangers with 0.75" minimum deflection.
<u>Vertical Pipe Risers:</u>	Use Type 6 hangers, Type AG anchors and guides as stated in Section 20 0529 - Mechanical Supporting Devices.
<u>Ductwork in Mechanical Equipment Rooms:</u>	Use Type 8 hangers with 0.75" minimum deflection for ducts with cross sectional area greater than 2.0 sq ft and where air velocity is greater than 2000 fpm for distance 50 ft from fan.
<u>Ductwork Suspended Underneath 1 thru 6 Floors:</u>	<p>Use Type 8 hangers with 0.75" minimum static deflection for ductwork under the following circumstances:</p> <p>Air velocities greater than 2000 fpm and duct cross sectional area greater than or equal to 2.0 sq ft.</p>

BLOWER MINIMUM DEFLECTION GUIDE

When blowers are 60 hp or larger, select deflection requirements for next larger span, but not less than 2-1/2".

<u>Fan Speed (rpm)</u>	<u>Required Deflection (Inches)</u>				
	<u>On Grade</u>	<u>Up to 20 ft Floor Span</u>	<u>20 ft to 30 ft Floor Span</u>	<u>30 ft to 40 ft Floor Span</u>	<u>40 ft to 50 ft Floor Span</u>
Up to 300	2.5	3.5	3.5	3.5	3.5
301-500	1.5	1.5	2.5	2.5	3.5
501 and over	0.75	1.5	1.5	2.5	3.5

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and adjust vibration isolation devices as specified, as shown on drawings and according to manufacturer's recommendations.
 - 1. Adjust isolators after piping system is at operating weight.
 - 2. 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.
 - 3. Adjust active height of spring isolators.
 - 4. Adjust restraints to permit free movement of equipment within normal mode of operation.
 - 5. Adjust air-spring leveling mechanism.
- B. In no case shall installation short circuit isolation devices.

3.2 FLEXIBLE PIPING CONNECTIONS

- A. Provide flexible connections for piping connected to rotating or reciprocating equipment, equipment such as coils mounted on vibration isolators, and as indicated on plans and details.
- B. Piping connected to coil which is in assembly where fan is separately isolated by vibration isolators and duct flexible connections does not require flexible piping connectors or piping vibration hangers.
- C. Piping connected to steam heating coils in floor mounted air handling units where coils are supported without vibration isolation shall have flexible piping connections and piping vibration hangers to prevent thermal stress in piping system from damaging the coils.
- D. Install flexible connections on equipment side of shut off valves and horizontal and parallel to equipment shafts where applicable.
- E. For non-metallic flexible piping connections, 2-1/2" and larger, use flange type recommended by manufacturer. Flanges for mechanical grooved connections are not allowed.

END OF SECTION

SECTION 23-0902 CONTROL DAMPERS

PART 1 GENERAL

1.1 RELATED WORK

- A. Section 23-3314 – Ductwork Specialties

1.2 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 GENERAL

- A. No devices containing mercury will be allowed under this Specification.

1.4 SUBMITTALS

- A. Product data sheets shall include construction materials and assembly methods, maximum design parameters (temperature, pressure, velocity, etc.), and performance data for full range of actuator stroke. Product data sheets shall include charts, graphics or similar items used in making selections, including damper to duct area ratio and free area ratio. Damper product data sheets shall indicate certified leakage rates for given pressure differentials.
- B. Submit damper schedules with shop drawings, indicating unique tag numbers for each device, equipment or system served, device model numbers, duct sizes, damper sizes, flow rates, pressure differentials, calculation of actual damper pressure drops, approach velocities, leakage rates, torque requirements, actuator model number, actuator torque capacities and pilot positioner locations.
- C. Select dampers to meet their intended service with respect to maximum approach velocities and maximum pressure differential. Damper materials shall match duct construction materials of systems in which they are installed (galvanized steel, aluminum, 304 or 316 stainless steel, etc.).
- D. Aluminum dampers may be used in galvanized steel ductwork.

1.5 DAMPER SELECTION AND SIZING

- A. Submit engineering calculations for sizing modulating control dampers including outside, return, and relief air dampers of air handling units unless dampers are scheduled.
- B. Calculations for sizing dampers shall be based on actual characteristics of ductwork system being installed. Opposed blade dampers shall be sized for minimum of 10% of duct section pressure drop. Parallel blade dampers shall be sized for minimum of 30% of duct section pressure drop. Duct section is defined as ductwork containing flow control damper starting with inlet or branch tee and ending with outlet or branch tee. Calculate actual duct pressure drops for each duct section containing modulating damper using latest version of ASHRAE Handbook of Fundamentals. If control systems fixes pressure drop, use those pressure setpoints. Use balance damper to provide additional pressure drop as required to obtain linear damper response.
- C. Control Contractor is responsible for obtaining adequate system information necessary for sizing.
- D. Two position dampers to be sized as close as possible to duct size, but in no case is damper size to be less than duct area.

- E. Submit leakage and flow characteristic data for control dampers along with shop drawings. Leakage ratings shall be based on AMCA Standard 500 and dampers shall bear AMCA Air Leakage Seals.

PART 2 PRODUCTS

2.1 CONTROL DAMPERS

- A. General:
 - 1. If control damper sizes are not shown or scheduled, refer to Part 1 of this Section for sizing criteria.
 - 2. Unless otherwise indicated, modulating control dampers shall be opposed blade or parallel blade type and 2-position (open/close) dampers shall be parallel blade type.
 - 3. Blade linkage hardware shall have corrosion-resistant finish and be readily accessible for maintenance.
- B. Standard Modulating and Two-Position Dampers:
 - 1. Manufacturers and acceptable model numbers:
 - a. Johnson Controls D-1200/D-1300 (Double Piece)
 - b. Honeywell D642/D643
 - c. Ruskin CD50/CD60
 - 2. Damper frames shall be minimum of 14 ga extruded aluminum. Blades shall be minimum of 14 ga aluminum. Blades shall have maximum blade width of 8" with steel trunnions mounted in bronze sleeve, nylon or ball bearings.
 - 3. Furnish dampers with blade seals and stainless steel side seals. Dampers and seals shall be suitable for maximum system temperature, pressure differential and approach velocity, but not less than temperature range of -40 to 200°F, pressure differential of 6" WG, and approach velocity of 4000 fpm.
 - 4. Dampers, when closed, shall be guaranteed by manufacturer not to leak air in excess of 8 cfm per sq ft at 4" WG differential static pressure.

2.2 SMOKE DAMPERS

- A. Manufacturers: Air Balance, Johnson Controls, Ruskin or Vent Products.
- B. Dampers shall be leakage rated at no higher than Leakage Class I (4 cfm/ft² at 1" WG and 8 cfm/ft² at 4" WG) under UL 555S at temperature category 250°F. Furnish dampers with factory-mounted, caulked sleeve and actuator assemblies. Damper shall have 16 gauge or heavier frame with air foil-shaped blades, rated to minimum 4" WG in closed position and to 2000 fpm in open position.

2.3 DAMPER ACTUATORS

- A. Damper actuators to be provided by controls contractor.

PART 3 EXECUTION

3.1 CONTROL DAMPERS

- A. Furnish and install control dampers & AHU isolation dampers.

- B. Control dampers shall be installed within AHUs as specified.

3.2 SMOKE DAMPERS

- A. Furnish and install smoke dampers at supply air outlet and return air inlet of each air handler.

END OF SECTION

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SECTION 23 2116 PIPE AND PIPE FITTINGS

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 20 0529 - Mechanical Supporting Devices
- B. Section 23 0594 - Water Systems Test Adjust Balance
- C. Section 23 0902 - Control Valves and Damper (Valves)
- D. Section 23 0903 - Control Instrumentation (Wells, Taps or In-line Devices)
- E. Section 23 2118 - Valves
- F. Section 23 2120 - Piping Specialties
- G. Section 23 2514 - Chemical Treatment Systems (Pipe Cleaning) – Issued under Core and Shell document package

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. This Section includes pipe and pipe fitting specifications and installation requirements for heating and cooling systems.
- B. Specification of an item in this or any other sections shall not relieve Contractor from providing all items, articles, materials, operations, methods, labor, equipment and incidentals necessary for a complete and functional system.
- C. Use only new material, free of defects, rust and scale, and guarantee for services intended.
- D. Use material meeting the latest revision of ASTM specifications as listed in this specification.
- E. Follow local codes if they require other types of pipe or joints.
- F. Use only long radius elbows having centerline radius of 1.5 pipe diameters unless otherwise indicated.
- G. Manufacturer, pressure class, size and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.
- H. Where size for a pipe segment is not indicated, the pipe segment size shall be equal to the largest pipe segment to which it is connected. Transition to smaller size shall occur on the side of fitting where smaller size is indicated.
- I. Unless otherwise indicated, fittings and accessories connected to pipe shall be of the same material as the pipe.

- J. Unless otherwise indicated, construct piping for highest pressures and temperatures in respective system in accordance with the latest revision of the applicable Sections of ASME Code for pressure piping, ASME B31 including the following:
1. B31.9 Building Services Piping
 2. B31.9 Building Service Piping for building heating and distribution steam and condensate piping for 15 psig or less, or hot water heating system for 30 psig or less
 3. B31.1 Power Piping
 4. B31.3 Process Piping
- K. Non-metallic piping is acceptable only for services indicated. It is not acceptable in occupied spaces and ventilation plenum spaces.

1.4 SUBMITTALS

- A. Shop Drawings for each piping system for all pipe sizes including, but not limited to, the following:
1. Name of system
 2. Pipe; ASTM number, grade if known, type, wall thickness, material
 3. Fittings; ASME number, grade if known, class, type, wall thickness, material
 4. Joint type
 5. Flanges; ASTM number, grade, class, type, material
 6. Bolts and nuts; material
 7. Thread joint sealants; material
 8. Flange gaskets; material, rating
 9. Unions; ASTM number, type, material, rating
 10. Type of welding
 11. Welding Quality Control Program
 12. Test pressure and media
 13. Pipe flushing/cleaning plan
 14. Pipe cleaning method
 15. All other appropriate data
- B. Submit pipe certification as specified under Pipe Certification in this Section.
- C. Submit required documents as specified under Pipe Welding in this Section.
- D. Provide Flushing and Cleaning Plan:
1. Submit pipe flushing/cleaning plan for water, fluid, steam and condensate systems for approval. Plan shall detail methods for compliance with requirements of this section, including:
 - a. Flushing and cleaning procedure narratives.
 - b. Size, power source, and connection points of contractor provided pumps that will be used for flushing and cleaning.
 - c. If Contractor proposes to utilize project system pumps, method of protecting pumps from damage and developing required velocity of section of piping to be flushed.
 - d. Method of sectionalizing piping to obtain required velocity.
 - e. Minimum velocities at each section of pipe, clearly indicating any sections where 6 fps cannot be achieved.

- f. Location and means of temporary bypasses for coils, control valves and other equipment.
- g. Flushing schedule and drawings or diagrams that will be used for inspection and sign off prior to and after procedure, at Owner's option.
 - 2. Submit documents showing verification of flushing/cleaning following specified requirements and results.

E. LEED Submittal

- 1. Product Data for IEQ Credit 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Furnish pipe with plastic end-caps/plugs on each end of pipe. Maintain end-caps/plugs through shipping, storage and handling to prevent pipe-end damage and eliminate dirt and construction debris from accumulating inside of pipe.
- B. Where possible, store materials inside and protect from weather. Where necessary to store outside, elevate well above grade and enclose with durable, waterproof wrapping.
- C. Before shipping, all carbon steel piping shall be free of rust and scale, and furnished with plastic end caps/plugs on each end of pipe.

1.6 PIPE WELDING

A. Procedure and Welding Qualification Records:

- 1. Submit Welding Procedure Specifications (WPSs) and their supporting Procedure Qualification Records (PQRs) to be used on the work to Engineer for review and approval prior to performing any welding. These documents shall meet requirements of ASME B31.1 and B31.9, as applicable.
- 2. Unless otherwise indicated, welding shall be done using only the following processes:
 - a. Shielded Metal Arc Welding (SMAW), also known as "stick" welding
 - b. Gas Tungsten Arc Welding (GTAW), also known as TIG and Heliarc welding
 - c. Gas Metal Arc Welding (GMAW), also known as MIG welding
 - d. Flux-Cored Arc Welding (FCAW), a variation of GMAW
 - e. Submerged Arc Welding (SAW)
 - 3. Root pass must be applied by GTAW process with argon gas purge for high-pressure steam and condensate (400 psig and over) and high temperature hot water (450°F and over) services.
 - 4. Root pass must be applied by only GTAW process with argon gas purge for stainless steel pipe.
 - 5. Unless otherwise stated, fabrication, installation, inspection, examination and testing shall be in accordance with ASME B31.1 or B31.9, as applicable.
 - 6. Backing rings (chill rings) or consumable inserts are not allowed, unless specifically requested by Owner or Engineer.

B. Quality Control Program:

- 1. Submit written quality control program for review and approval prior to implementing any welding on this project. Quality control program shall include the following as minimum:
 - a. Explanation of how Contractor will assure proper fitup for each weld.

- b. Explanation of how Contractor will document welds performed by individual welding operators for systems under ASME B31.1.
- c. Explanation of how Contractor will assure that proper welding procedure is being followed.
- d. Credentials of personnel responsible for required weld examinations.

C. Weld Inspection and Examination:

1. Provide examination services for all welding for this Project. Examination shall be in accordance with requirements of ASME B31.1, Table 136.4 or B31.9, as applicable.
2. Periodically, as welding progresses, submit report, signed by weld examiner, indicating status of project welding quality.
3. Arrange with Owner's Inspector for observation of fitup and welding methods prior to implementing any welds, including shop welds, on this Project.
4. In addition, Owner's Inspector will perform any additional observations deemed necessary before, during, or after fabrication to assure, to Owner's satisfaction, that proper welding is provided. Owner reserves the right to perform independent examination of welds. If Owner has any concern as a result of such examination Owner reserves the right to stop in progress welding work, without any cost to Owner, until resolution satisfactory to Owner is reached.

D. Welder Qualifications:

1. Each welder and welding operator must qualify by passing required procedure test before performing any project welds. Submit copy of Manufacturer's Record of Welder or Welding Operator Qualification Tests (WPQS) as required by Section IX of ASME Boiler and Pressure Vessel Code for all welding procedures to be performed by welding operator.
2. Welder qualifications must be current. If qualification test is more than 6 months old, provide record of welding continuity for each welder.
3. Record of welding continuity is intended to show that welder has performed welding at least every 6 months since the date that welder qualification test was passed for the submitted welding procedure specification.
4. Record of welding continuity shall include, at minimum, the following:
 - a. Welder's employer name and address
 - b. Date Welder Qualification Test was passed
 - c. Dates indicating welding continuity
5. Welders shall be qualified as required by ASME B31.1 or B31.9, as applicable. In addition, there shall be an independent witness of welder tests. That witness shall be representative of independent testing laboratory, Authorized (Code) Inspector, Owner's or Engineer's Inspector or consultant approved by National Certified Pipe Welding Bureau.
6. Welder qualifications must cover all pipe sizes and wall thickness used on this project. Test segments or coupons shall be appropriately selected for qualification. Test position shall be arranged in "6G position."

E. Weld Record:

1. For welding within the scope of ASME B31.1 Power Piping, submit to Engineer for approval an administrative procedure for recording, locating, monitoring and maintaining quality of welds to be performed on the project. This quality control document record shall include but not be limited to:

- a. Drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date, and WPS used.

1.7 PIPE CERTIFICATION

- A. Certification is required for all pipe within scope of ASME B31.1. Submit certification papers, as outlined below, within 30 days of delivery of pipe to project site.
- B. Type E or S Pipe:
 1. Furnish manufacturer's mill certificates (material test report) including dimensions, heat numbers, chemical analysis and tensile test results for pipe shipped to project site.

1.8 CATHODIC PROTECTION

- A. Cathodic protection shall be designed and provided by system pre-insulated pipe manufacturer for pipe systems as specified in Part 2. Cathodic protection shall conform to recognized practices and shall be designed by qualified personnel. Measurements of corrosivity of soil environment expressed in terms of soil's electrical resistivity (ohm/cm) shall be taken and checked out by pre-insulated pipe manufacturer. Resistivities shall be given along proposed routing of piping systems. Anodes and test stations shall be provided by this Contractor as recommended by pre-insulated pipe manufacturer.
- B. After installation, field survey shall be made by pre-fabricated pipe manufacturer and measurement of current and conduit-to-soil potentials at each test station shall be taken.

PART 2 - PRODUCTS

2.1 LOW PRESSURE STEAM (15 PSIG AND LOWER)

- A. 2" and Smaller:
 1. Pipe: ASTM A53, Grade A or B, Type E or ASTM A106, Grade B, Schedule 40, carbon steel
 2. Fittings: ASME B16.3, Class 150 malleable iron, threaded
 3. Unions: ASME B16.39, malleable iron, Class 150. Refer to Unions and Flanges in this Section
- B. 2-1/2" and Larger:
 1. Pipe: ASTM A53, Grade A or B, Type E or ASTM A106, Grade B, Schedule 40, carbon steel
 2. Fittings: ASTM A234 Grade WPB/ASME B16.9, standard weight, seamless, carbon steel weld
 3. Flanges: Class 150. Refer to Unions and Flanges in this Section

2.2 LOW PRESSURE STEAM CONDENSATE (15 PSIG AND LOWER)

- A. 2" and Smaller:
 1. Pipe: ASTM A53, Grade B Type F, Schedule 80 extra strong, carbon steel
 2. Fittings: ASME B16.3, Class 300 malleable iron, threaded
 3. Unions: ASME B16.39, malleable iron, Class 300. Refer to Unions and Flanges in this Section

B. 2-1/2" and Larger:

1. Pipe: ASTM A53, Grade B, Type E or ASTM A106, Grade B, extra strong, schedule 80 carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, extra strong, seamless, carbon steel weld
3. Flanges: Class 150 250. Refer to Unions and Flanges in this Section

2.3 HIGH PRESSURE STEAM CONDENSATE

A. 2" and Smaller:

1. Pipe: ASTM A106, Grade B, extra strong, schedule 80, carbon steel
2. Fittings: ASME B16.3, Class 300 malleable iron, threaded
3. Unions: ASME B16.39, malleable iron, Class 300. Refer to Unions and Flanges in this Section

B. 2-1/2" and Larger:

1. Pipe: ASTM A106, Grade B, extra strong, Schedule 80, carbon steel
2. Fittings: ASTM A234, Grade WPB/ASME B16.9, extra strong, seamless, carbon steel weld fittings
3. Flanges: Class 300. Refer to Unions and Flanges in this Section

2.4 HIGH PRESSURE STEAM (16 PSIG AND ABOVE)

A. 2" and Smaller:

1. Pipe: ASTM A106, Grade B, schedule 40, extra strong, carbon steel
2. Fittings: ASME B16.3, Class 300 malleable iron, threaded
3. Unions: ASME B16.39, malleable iron, Class 300 250. Refer to Unions and Flanges in this Section

B. 2-1/2" Thru 8":

1. Pipe: ASTM A106, Grade B, schedule 40, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, schedule 40, seamless, carbon steel weld
3. Flanges: Class 300. Refer to Unions and Flanges in this Section

C. 10" and Larger:

1. Pipe: ASTM A106, Grade B, 1/2" wall thickness, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, extra strong, schedule 40, seamless, carbon steel weld
3. Flanges: Class 300. Refer to Unions and Flanges in this Section

2.5 STEAM CONDENSATE PUMP DISCHARGE

A. 2" and Smaller:

1. Pipe: ASTM A106, Grade B, schedule 80 extra strong, carbon steel
2. Fittings: ASME B16.3, Class 300 malleable iron, threaded
3. Unions: ASME B16.39, malleable iron, Class 300. Refer to Unions and Flanges in this Section

B. 2-1/2" and Larger:

1. Pipe: ASTM A106, Grade B, extra strong, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, extra strong, seamless, carbon steel weld
3. Flanges: Class 300. Refer to Unions and Flanges in this Section

2.6 HEATING HOT WATER

A. 4" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube
2. Fittings: ASME B16.22, wrought copper solder joint
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for line sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 250, cast copper alloy
6. Use solder joints for valves and piping specialties in copper piping

B. 6" and Larger:

1. Pipe: ASTM A53, Grade B, Type E or ASTM A106, Grade B, schedule 40, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, schedule 40, seamless, carbon steel weld
3. Flanges: Class 250. Refer to Unions and Flanges in this Section

2.7 CHILLED WATER/MEDIUM TEMPERATURE CHILLED WATER

A. 4" and Smaller:

1. Pipe: ASTM B88 seamless, Type L, hard temper copper tube
2. Fittings: ASME B16.22, wrought copper solder joint
3. Joint: ASTM B32, lead free solder, Bridgit, Silvabrite, Silverflow or Canfield
4. Unions: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper solder joint, Class 125. No unions to be used for lines sizes 3/4" and smaller. Unions shall be used for line sizes over 1".
5. Flanges: ASME B16.24, Class 250, cast copper alloy
6. Use solder joints for valves and piping specialties in copper piping.

B. 6" and Larger":

1. Pipe: ASTM A53, Grade B, Type E or ASTM A106, Grade B, schedule 40, carbon steel
2. Fittings: ASTM A234 Grade WPB/ASME B16.9, schedule 40, seamless, carbon steel weld
3. Flanges: Class 250. Refer to Unions and Flanges in this Section

- C. *All Chilled water piping systems to be designed for 250PSIG working pressure, including pumps, valves, strainers, and fittings.*

2.8 VENTS AND RELIEF VALVES

- A. Unless otherwise indicated, use pipe and pipe fittings as indicated for the system to which relief valve or vent is connected.
- B. ASTM A53, Type F, carbon steel pipe with schedule 40, carbon steel fittings may be used for steam vents smaller than 4".
- C. Use ASTM A53, Type E carbon steel pipe with ASTM A234 Grade WPB/ASME B16.9, schedule 40, seamless carbon steel weld fittings for refrigerant vent piping.

2.9 PRESSURE GAUGES AND TAPPINGS

- A. Use pipe and pipe fittings as indicated for the system to which pressure gauge or tapping is connected. Use "Threadolets", "Sockolets" or tee fittings for tappings. Refer to Part 3 under General for use of "Threadolets" and "Sockolets".
- B. Gauge pipe shall be 1/4" unless otherwise indicated.
- C. Gauge pipe shall be 1/2" for high pressure steam (101 psig and over) systems.

2.10 COOLING COIL CONDENSATE DRAIN

- A. Piping shall be one of the following, unless otherwise indicated on drawings:
 - 1. Pipe: ASTM B88, Type L, hard temper copper tubing
 - 2. Fittings: ASTM B16.22 wrought copper fittings
 - 3. Joint: ASTM B32, lead free solder, Bridgit or Silvabrite

2.11 DIELECTRIC UNIONS, FLANGES AND FITTINGS (STEEL PIPE TO COPPER PIPE)

- A. 2" and Smaller:
 - 1. Use bronze ball valves specified in Section 23 2118 for dielectric purpose.
 - 2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2" and smaller.
 - a. Clearflow fittings shall be ASTM A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.
 - 3. ASTM A197/ASME B16, equal to Stockham Figure 693-1/2, Watts Series 3000 or Wilkins (Zurn) Model DU series dielectric unions with EPDM dielectric gasket, 250 psi at 180°F.
- B. 2-1/2" through 4":
 - 1. Watts dielectric flange fittings Series LF 3100/LF 3110 with dielectric gasket, 175 psi at 180°F.
 - 2. Dielectric fittings similar to Victaulic Style 647 or Clearflow Dielectric Waterway fittings may be used in lieu of dielectric unions for pipe sizes 2-1/2" and larger.
 - a. Clearflow fittings shall be ASTM A53 electro zinc-plated steel pipe with high temperature polyolefin polymer liner, suitable for continuous use at temperatures up to 230°F and pressures up to 300 psig.

2.12 DIELECTRIC UNIONS, FLANGES AND FITTINGS (STEEL TO STEEL PIPE)

- A. 1" and Smaller: Similar to Epco model HA-B with dielectric gasket, 250 psi at 210°F

- B. 1-1/2" and Larger: Similar to Epco model W with bolt insulators, dielectric gasket, bolts and nuts, 175 psi at 210°F). Pikotek model VSC dielectric gasket with viton sealing element, G-10 sleeve and double washers, suitable to 350°F, may be used with specified flanges.

2.13 UNIONS AND FLANGES

A. Unions:

1. 2" and Smaller: Malleable iron, ASME B16.39 with ground joint, bronze or brass to iron. Provide black malleable iron for carbon steel piping and galvanized malleable iron for galvanized steel piping. Unless otherwise specified, pressure class and joint type of union shall be equal to that specified for fittings of respective piping service. Minimum pressure class of unions shall be Class 250.
2. 2" and Smaller: Forged steel, ASTM A105 Grade 2, ASME B16.11, 300 lb WOG with steel to steel seats. Joint type shall match that specified for fittings of respective piping service.

B. Flanges:

1. 2-1/2" and Larger: ASTM A105, ASME B16.5, hot forged steel, welding neck pattern. Slip-on pattern are not allowed. Bore dimension of welding neck flange shall match inside diameter of connected pipe.
2. Use raised face flanges for mating with other raised face flanges with self-centering flat ring gaskets. Use flat face flanges for mating with other flat face flanges with full face gaskets.
3. Flange pressure class indicated in respective piping service is minimum required. Mating flange pressure class shall match pressure class of connected device, such as valves and piping specialties.

C. Flange Gaskets:

1. General - Gasket material shall be asbestos free and suitable for pressures, temperatures and fluid of respective piping system. Non-metallic gaskets shall be in accordance with ASME B16.21 and ASTM F104.
2. Service Temperature (through 249°F) – Garlock, Klingersil or J.M. Clipper, similar to Garlock 5500. Gaskets similar to Garlock Style 3000 may be used for hydronic piping. Unless otherwise indicated or recommended by manufacturer, gaskets shall be compressed inorganic fiber with nitrile binder 1/16" thick for flanges 12" and smaller and 1/8" thick for flanges 14" and larger.
3. Service Temperature (250°F thru 800°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, 304 SS winding, carbon steel centering ring, 0.175" thickness.
4. Service Temperature (801°F thru 1500°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, 316 SS winding, carbon steel centering ring, 0.175" thickness.
5. Service Temperature (1501°F thru 1700°F) - Flexitallic, Garlock, Lamos equal to Flexitallic Style CG, flexible graphite filler, Inconel 600 winding, 316 SS centering ring, 0.175" thickness.

D. Bolting:

1. Bolts, bolt studs, nuts and washers shall have zinc plated finish.
2. Thread shall be in accordance with ASME B1.1, Class 2A tolerance for external threads and Class 2B tolerance for internal threads. Threads shall be coarse-

thread series except that alloy steel bolting 1/8" and larger in diameter shall be 8 pitch thread series.

3. Threaded rods are not allowed as fastening elements.
4. For Class 150 and Class 300 flanges not exceeding 400°F temperature, use carbon steel bolts or stud bolts conforming to ASTM A307, Grade B with nuts conforming to ASTM A194.
 - a. Bolts conforming to ASTM A307, Grade A may be used for piping governed by ASME B31.9.
5. For Class 400 and 600 flanges at 750°F or lower temperature, use alloy steel bolts or stud bolts conforming to ASTM A193, Grade B7 or B16, with nuts conforming to ASTM A194, Grade 2H.

2.14 THREADED JOINT SEALANTS

- A. Paste type for brush application or cord type. Products shall be non-toxic, chemically inert, non-hardening, rated for -50°F to 400°F and up to 10,000 psi (liquids) and 3000 psi (gases), certified by UL, CSA, and NSF.
- B. Use sealant similar to Loctite Model 54531 for piping handling oil or petroleum products.

2.15 WELD BRANCH OUTLET FITTINGS (WELDOLETS, THREADOLETS AND SOCKOLETS)

- A. Weld branch outlet fittings shall conform to MSS-SP-97, ASME B16.9 for weldolets, ASME B1.20.1 for threadolets and ASME B16.11 for sockolets.
- B. Materials shall match material of header piping and wall thickness of outlet or branch end shall match wall thickness of branch pipe.

PART 3 - EXECUTION

3.1 GENERAL

- A. Remove foreign materials before erection. Ream ends of piping to remove burrs.
- B. Install piping parallel to building walls and ceilings and at such heights so as not to obstruct any portion of window, doorway, stairway, or passageway. Install piping to allow adequate service space for equipment. Refer to drawings and/or manufacturer's recommendations. Install vertical piping plumb. Where interferences develop in field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings or other architectural details before installing piping.
- C. Provide anchors, expansion joints, swing joints and expansion loops so that piping may expand and contract without damage to itself, equipment or building.
- D. Mitered elbows, welded branch connections, notched tees and "orange peel" reducers are not allowed. Unless specifically indicated, reducing flanges and reducing bushings are not allowed. Reducing bushings may be used for air vents and instrumentation connections.
- E. Unless otherwise indicated, use fittings as specified in Part 2 of this Section for elbows, tees, reducers, etc.
- F. "Weldolets" with outlet size 2-1/2" and larger and "Threadolets" or "Sockolets" with outlet size 2" and smaller may be used for branch connections up to one pipe size smaller than main. Use

"Threadolets" where threaded fittings are specified and use "Sockolets" where socket weld fittings are specified. Install in accordance with PFI (Pipe Fabrication Institute) Standard ES49.

- G. Install drains throughout systems to permit complete drainage of entire system.
- H. Do not install piping over electrical panelboards, switchgear, switchboards or motor control centers.
- I. Install valves, control valves and piping specialties, including items furnished by others, as specified and/or detailed.
- J. Make connections to all equipment installed by others where that equipment requires piping services indicated in this Section.
- K. For piping within the scope of ASME B31.1 Power Piping, transfer piping material specification and "Heat Number" to each segment of pipe prior to cutting.

3.2 THREADED PIPE JOINTS

- A. Threads of pipe and fittings shall conform to ASME B1.20.1.
- B. Ream pipe ends after cutting and clean before erection. Apply thread sealants to cleaned male threads. Assemble joint to appropriate depth and remove any excess pipe joint compound from tightened joint.

3.3 FLANGED JOINTS

- A. Clean flange surfaces and align them parallel. Bolt holes of gaskets shall be cut slightly larger than bolt diameter. Gasket ID shall be slightly larger than flange ID.
- B. Position gasket concentrically so compression is equally distributed over entire gasket surface.
- C. Lubricate bolts and run nuts down by hand.
- D. By using torque wrench, tighten nuts in the proper sequence so gasket is compressed evenly, and to the appropriate torque specified by bolt manufacturer.
- E. Re-torque bolts 12 to 24 h after start up.

3.4 WELDED PIPE JOINTS

- A. Inspect pipe and pipe fittings for roundness before they are fit-up or set in place.
- B. Properly clean and prepare pipe base material before fit-up. Verify joint land and bevel.
- C. Preheat pipe base material as required by welding procedure specification. Temperature of pipe material must be minimum of 32°F before welding.
- D. Properly align and adjust joint as required by welding procedure and thickness of material. Verify tolerances after tacking sequence.
- E. Use weld material diameter as procedurally required for type and thickness of work being done.
- F. Use sufficient argon pre-purge and argon post-purge for GTAW processes. Post purge should be until weld is no longer glowing plus 5 seconds. Maintain purge for at least 2 layers of weld material.
- G. Properly store welding materials.

- H. Clean tacks before welding out. Remove slag after each pass by grinding to avoid slag inclusion.
- I. Weld reinforcement shall not exceed limits established in Chapter V of ASME B31.1.
- J. Brush each weld free of rust and paint with rust resistant product that matches piping surface color.
- K. For piping within scope of ASME B31.1, each weld shall be permanently marked by welder performing weld. Each welder shall sign and date field welding log record for all welds performed by welder as indicated in Part 1.
- L. Conduct radiographic test for sections or joints that cannot be tested by hydrostatic test methods (such as joints cut into existing piping systems) by qualified radiographic testing firm.

3.5 COPPER PIPE JOINTS

- A. Cutting of tubing shall not make tubing out of round. Ream cut tube ends to full inside diameter.
- B. Remove slivers and burrs remaining from tube cut by reaming and filing both pipe surfaces. Clean fitting and tube with emery or sand cloth. Remove residue from cleaning operation, apply flux and assemble joint. Use solder or brazing to secure joint as specified for specific piping service.

3.6 STEAM AND STEAM CONDENSATE

- A. Pitch steam mains down at 1" per 40 ft in direction of flow. Pitch runouts to terminal equipment and control valves at 1/2" per 1 ft for proper condensate drainage. Install drip traps at each rise and at horizontal termination of each steam main.
- B. Pitch steam condensate lines down at 1" per 20 ft in direction of flow.
- C. Unless otherwise indicated, use eccentric fittings for changes in horizontal pipe sizes with fittings installed for proper condensate drainage (bottom of pipe straight). Concentric fittings may be used for changes in vertical pipe sizes.
- D. For steam branch connections and runouts, use top or top 45° connection to main.
- E. For condensate branch connections to condensate mains, use top or top 45° connection to main.
- F. For condensate connections from steam mains, use bottom connection to main.
- G. Install minimum of 3 elbows in each pipe runout to terminal equipment to provide flexibility for expansion and contraction of piping system.

3.7 WATER SYSTEMS

- A. Unless otherwise indicated, install horizontal piping level. Install manual air vents at all high points where air may collect. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.
- B. Main branches and runouts to terminal equipment may be made at top, top 45°, side or bottom 45° of main provided that there are drain valves suitably located for complete system drainage and manual air vents are located as described above.
- C. Unless otherwise indicated, use top or top 45° connection to main for upfeed risers, and use side or bottom 45° connection to main for downfeed risers. Bottom connection is not allowed.

- D. Use minimum of 3 elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems. Offset pipe connections at equipment to allow for service, such as removal of terminal device.
- E. Unless otherwise indicated, use concentric fittings for changes in pipe sizes and for valves smaller than pipe sizes.
- F. Notch and dimple branch tubes. Braze joints. Apply heat properly so that pipe and tee do not distort. Remove distorted connections.
- G. Where mechanically formed tee fittings are allowed, form mechanically extracted collars in continuous operation, consisting of drilling pilot hole and drawing out tube surface to form collar having height of not less than 3 times thickness of tube wall. Collaring device to be adjustable.

3.8 VENTS AND RELIEF VALVES

- A. Install vent and relief valve discharge lines as indicated on drawings, as detailed, and as specified for each specific valve or piping specialty item.

3.9 COOLING COIL CONDENSATE DRAIN

- A. Trap each cooling coil drain pan connection with trap seal of sufficient depth to prevent conditioned air from moving through piping. Extend drain piping to nearest code approved drain location. Construct trap with plugged tee for cleanout purposes.
- B. Pitch pipe down at 1/4" per one foot for proper drainage.

3.10 DIELECTRIC UNIONS AND FITTINGS

- A. Install dielectric unions, flanges or fittings in main and branch piping of water systems at each point where copper to steel pipe connection occurs. Dielectric unions or fittings shall not be used at terminal device connections.
- B. Concealed dielectric unions and fittings are not allowed.
- C. Install steel to steel pipe dielectric unions or flanges in chilled water, steam and steam condensate piping at each point where interior steel piping is connected to exterior underground steel piping.

3.11 UNIONS AND FLANGES

- A. Install union or flange at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair or replacement. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
- B. Concealed unions or flanges are not allowed.

3.12 PIPING SYSTEM PRESSURE TESTS

- A. Owner and/or Owner's representative may elect to witness pressure test. Notify Owner and/or Owner's representative at least 3 days in advance.
- B. Conduct pressure test prior to flushing and cleaning of piping systems.

- C. Conduct hydrostatic (HYDRO) test in accordance with ASME B31.1 137.4. Test pressure shall be in accordance with ASME B31.1, but shall not be lower than the minimum test pressure listed below.
- D. Conduct Pneumatic (PNEU) test with test medium of dry, oil free air, carbon dioxide, or nitrogen for natural gas, compressed air and fuel oil piping and in accordance with ASME B31.1 137.4.
- E. If leaks are found, repair with new materials and repeat test until leaks are eliminated. Caulking will not be acceptable.
- F. Pressure tests may be made of isolated portions of piping systems to facilitate general progress of installation. Any revisions made in piping systems require retesting of affected portions of piping systems.
- G. No systems shall be insulated until it has been successfully tested. If required for additional pressure load under test, provide temporary restraints at expansion joints or isolate them during test. Unless otherwise noted, minimum test time shall be 4 h plus such additional time as may be necessary to conduct examination for leakage.
- H. No pressure drop shall occur during test period. Any pressure drop during test period indicates leakage.
- I. Provide pumps, gauges, instruments, test equipment, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.
- J. For hydrostatic tests, remove air from piping being tested by means of air vents. Measure and record test pressure at high point in system. Where test pressure at high point in system causes excessive pressure at low point in system due to static head, portions of piping system may be isolated and tested separately to avoid undue pressure. However, every portion of piping system must be tested at the specified minimum test pressure.
- K. Conduct pressure tests with parameters indicated below:

<u>System</u>	<u>Minimum Test Pressure</u>	<u>Remarks</u>
Low pressure steam and condensate	75 psig	HYDRO
High pressure steam and condensate		
16 thru 100 psig	150 psig	HYDRO
101 thru 200 psig	250 psig	HYDRO
201 thru [XXX] psig	[300] [XXX] psig	HYDRO
Steam condensate pump discharge	100 psig	HYDRO
Heating hot water	100 psig	HYDRO
Chilled water/medium temperature chilled water	100 psig	HYDRO

Glycol water

100 psig

HYDRO

L. Underground Water Piping:

1. Underground chilled water piping shall be leakage rate tested. Leakage rate test may be conducted at the same time as hydrostatic pressure test. Leakage rate is defined as quantity of water that must be supplied into the respective underground piping system to maintain specified hydrostatic test pressure after air in piping system has been removed and piping system has been filled with water.
 2. Determine maximum allowable amount of leakage by the following formula:
 - a. $L=SD(P)^{1/2}/200,000$ where: L = allowable leakage in gallons per hour, S = length of pipe tested in feet, D = nominal diameter of pipe in inches, P = average test pressure during leakage test in pounds per square inch (PSIG)
 3. If measured leakage rate exceeds maximum allowable leakage rate, repair with new materials and repeat test; caulking is not allowed. Conduct all testing in presence of Engineer. Coordinate all testing with Engineer and Owner at least 2 days in advance of its occurrence.
- M. Contractor shall provide all pumps, gauges, instruments; test equipment, flow meters, temporary piping and personnel required for tests and provide removal of test equipment and draining of pipes after tests have been made.
- N. If piping system is drained after testing and left empty or untreated for more than 3 days, add Nalco 2572 at recommended dosages for dry system lay-up.
- O. High Pressure Steam and Condensate Piping (181 thru 600 psig/700°F):
1. Test piping systems using hydrostatic and initial service test in accordance with procedures outlined in Chapter VI, Section 137 of ASME B31.1 Power Piping Code.
 2. Successfully complete 800 psig hydrostatic test before proceeding to initial service test.
 3. Initial Service Test, gradually increase piping pressure and temperature in steps of approximately one-tenth of final operating conditions until final operating conditions are reached.

3.13 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Notify Owner and/or Owner's representative at least 7 days in advance.
- B. Flush new water, fluid, steam and condensate systems thoroughly for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system. Bypass pumps and equipment and remove strainers from strainer bodies. Provide circulation by Contractor-supplied portable pumping apparatus.
- C. Provide temporary piping or hose to bypass coils, control valves, heat exchangers, other factory-cleaned equipment, and any component that may be damaged.
- D. Sectionalize system to obtain minimum velocity of 6 fps. Provide temporary piping to connect dead-end supply and return headers as necessary. Flush bottoms of risers.
- E. For pipes 18" and larger, maintain velocity as close as 6 fps possible, but not below 5 fps.

- F. After initial flushing of system, use portable pumping apparatus to circulate cold water detergent for water systems. Refer to Section 23 2514 - Chemical Treatment Systems for pipe cleaning.
- G. After initial flushing of system, use portable pumping apparatus for continuous 24 h minimum circulation of cold water detergent similar to Nalco 2567 cleaner. Flush detergent clear with continuous draining and raw water fill for additional 12 h or until all cleaner is removed from system. Replace strainers and reconnect permanent pumping apparatus and all apparatus bypassed.
- H. Refer to Section 23 2514 - Chemical Treatment Systems for water analysis – Issued under Core and Shell document package.
- I. Use oil when flushing hydraulic piping.
- J. Flush gas piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.
- K. Flush compressed air piping with clean, dry compressed air for one (1) h minimum. Open and clean drip legs. Repeat flushing until no debris is found in drip legs.

3.14 FLUSHING AND CLEANING CHILLED WATER PIPING SYSTEM

- A. Contractor shall visually inspect internal portion of each length of pipe during installation. Remove all dirt and foreign matter prior to installing additional lengths. After each major section of piping has been installed, it shall be cleaned and flushed utilizing a high pressure water “hydro-jet” process. The hydro-jet process involves passing a high pressure, high volume spray type cleaning head through the piping. The head is inserted in each section of piping and activated with full water pressure and flow. Through hydraulic force from directional spray nozzles the head propels itself forward up the pipe section. Once the head reaches the end of the pipe section it is retracted while maintaining maximum water pressure and flow. The length of the piping section shall be determined ahead of time so that the proper amount of travel can be tracked with calibrated markings on the spray head feed water hose or a meter on the hose reel. While traveling through the piping the pressurized water spray knocks debris loose and carries it back to the open end of the piping where it is collected and removed from the system. For each section of piping the process shall be performed a minimum of two times and shall be repeated until the water exiting the end of the pipe is clear and free of debris as determined by the Owner/Engineer.
- B. The hydro-jet equipment utilized shall be capable of providing a minimum of 50 gpm at 2000 psi.
- C. All cleaning and flushing shall be performed such that all debris will be pulled or flushed downhill.
- D. All cleaning and flushing shall be initiated from all low points in the system and shall terminate at the nearest adjacent high point in the system.
- E. Coordinate the limitations and requirements of hydro-jet process with the flushing subcontractor such that the piping is installed in a sequence and manner that allows every section of the new pipeline to be cleaned and flushed. Limitations may include maximum length of the pipe section, maximum number and/or degree of bends in the pipe section, maximum slope of the pipe section, equipment and excavation access requirements, and the minimum size of the openings required in the piping to allow for insertion and retraction of the cleaning head.
- F. Contractor shall provide access at all low points through valves, tees, flanges, etc. to facilitate the cleaning and flushing process. If temporary fittings or piping is required, it shall be provided by the Contractor and removed by the Contractor after successful cleaning.

- G. After flushing and cleaning is completed, Contractor shall provide necessary pipe and fittings required to complete the piping system. Each cleaned section of piping shall be capped and protected to keep mud, debris, water, etc. from entering the piping. If a piping section is left open or unprotected, or is found to be contaminated, it shall be re-cleaned prior to being filled and activated at no cost to the Owner.
- H. Contractor shall provide all water for flushing and testing. Coordinated rental of fire hydrant meters with local Fire Department(s), or the University as required.
- I. Contractor shall provide all temporary piping from water source to piping system and shall provide means for conducting cleaning water from underground piping system to the appropriate sewer; i.e. pumps, piping, hoses, tanks, etc. Contractor to remove all temporary piping, pumps, hoses, etc. from site immediately after flushing has been completed.

3.15 INITIAL SYSTEM FILL AND VENT

- A. Fill and vent systems with proper working fluids.
- B. Use fluids chemically treated as specified in Section 23 2514 - Chemical Treatment Systems. – Issued under Core and Shell document package
- C. Glycol system shall be filled with treated glycol as specified in Section 23 2514 - Chemical Treatment Systems.

3.16 PIPE PAINTING

- A. Exposed exterior carbon steel, black iron or other ferrous pipe and fittings shall be prepared and painted by qualified painters using corrosion inhibitive paints. Pipe shall be prepared in accordance with paint manufacturer's instructions and primed (2 coats) and finish painted (2 coats). Paint type shall be approved by Architect/Engineer.
- B. Protect piping from weather and paint promptly to prevent corrosion. Coordinate painting requirements with Architect. Usually all painting on unfinished materials installed by Mechanical Contractor is performed by General Contractor. If GC is not involved in a project, specify above as minimum. If large amount of painting is required for exterior and interior piping, ductwork or equipment, consider to specify painting requirements in an independent section. Verify with Owner for any color coding required for piping system.

END OF SECTION

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SECTION 23 2118 VALVES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 20 0700 - Mechanical Systems Insulation
- B. Section 23 0902 - Control Valves and Dampers
- C. Section 23 2120 - Piping Specialties (Flow Sensors and Meters)

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

- A. Shop Drawings for each system for all sizes including, but not limited to, the following:
 - 1. Name of system
 - 2. Manufacturer's name
 - 3. Type
 - 4. Model number
 - 5. Materials of construction
 - 6. Temperature/pressure ratings
 - 7. Manufacturer's data sheets clearly cross-referenced
 - 8. All other appropriate data

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Gate valves, globe valves, check valves, and drain valves: Crane, Nibco, Stockham, Powell, Milwaukee, Hammond, or Grinnell equal to manufacturer's Figure number listed. Provide valves of same make for these services.
- B. Other valves: acceptable manufacturers and Figure Number listed under each item.

2.2 WATER SYSTEM VALVES – HEATING WATER

- A. General:
 - 1. Valves 2" and smaller in steel piping shall have threaded ends.
 - 2. Valves 2" and smaller in copper piping shall have solder ends.
 - 3. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.

B. Ball Valves:

1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port for 3/4" and smaller and conventional port for 1" and larger, Teflon seat rings, blowout-proof stem, 2-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T(S)-580-70, Apollo No. 70, Watts, Milwaukee BA-150, Hammond, Kitz or Anvil

C. Spring Loaded Check Valves:

1. 2" and Smaller: bronze or iron body, Class 150 (200 psi WOG), Nibco Figure T(S)-480, Mueller Figure 303-AP or Metraflex No. 700
2. 2-1/2" and Larger: cast iron or ductile iron body, flanged or wafer type, 302/304 or 316 stainless steel spring, aluminum bronze, carbon steel or ductile iron totally encapsulated in EPDM disc, Buna-N or electroless nickel plated seat, Class 150 (200 psi WOG), Nibco Figure F-910 or W-910, Milwaukee 1800 or 1400, Metraflex No. 700, Stockham Figure WG-970, Mueller Sure Check Model No. 71, or Crane Duo-check II
3. For valves 8" and larger, provide lifting lugs or threaded holes for lifting eye bolts.

D. Shut-Off Valves:

1. 2" and Smaller: ball valves as specified in this Section
2. 2-1/2" and Larger: butterfly valves as specified in this Section

E. Balancing Valves:

1. 2" and Smaller: calibrated balancing valves:
 - a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour & Andersson (Victaulic) Series 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by Flow Design Inc. (FDI), Presco, Gerand, Nexus, HCl or Taco. Bronze or brass body, 250 psi maximum working pressure, 250°F maximum operating temperature. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
 - b. Valves shall measure down to 0.3 gpm with accuracy of $\pm 5\%$.
 - c. Valves shall be leak-tight at full rated working pressure.
 - d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.
2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson (Victaulic) Series 788/789, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature. Fixed orifice with ball valve or butterfly valve as manufactured by FDI, Presco or Gerand, Class 150 flange, 225 psi maximum working pressure, 250°F maximum operating temperature will be acceptable up to 4" size. Butterfly valves, as specified in this Section, together with averaging Pitot tube flow sensors, as specified in Section 23 2120 - Piping Specialties, under Flow Sensors and Meters between check valve and butterfly valve may be used when sizes for Armstrong or T/A valves are not available. Furnish butterfly valves with adjustable memory stops to limit return of valves to preset open position after shut-off.
3. Furnish portable meter kit within durable case similar to Gerand Model "R". Furnish meter with minimum 4-1/2" diameter aluminum or brass body/brass internals with reading range of either 0" to 50" or 0" to 100" water column differential as appropriate, 200°F maximum temperature, 300 psi working pressure. Meter accuracy shall be $\pm 2\%$ full scale. Provide in kit: equalizing valves, 10 ft purge hose and size devices specified. Meter shall become property of Owner.
4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

F. Terminal Unit Valve Assembly

1. Terminal unit valve assembly may be used instead of individual valve and other components, provided each valve and component meets specified requirements.
2. Victaulic, Nexus, Griswold, HCl or FDI are acceptable.
3. Inlet assembly shall be combination of isolation ball valve, y-strainer, union, and PT test port similar to Victaulic Coil Pack Series 78 Y, and outlet assembly shall be combination of isolation ball valve, union, PT test ports and balancing valve similar to Victaulic Coil Pack Series 78K and 784.

G. Butterfly Valves:

1. 2-1/2" and Larger:
 - a. Manufacturers: DeZurik, Keystone, Nibco, Milwaukee, or Bray
 - b. Ductile iron body, stainless steel shaft, aluminum-bronze disc, or Nylon 11 coated ductile iron disc, upper thrust bearing, EPDM resilient seat, rated at 200 psi bidirectional shut-off pressure, suitable for continuous operation at temperature up to 225°F, compatible to ANSI B16.1 Class 125/150 flange standards, conforming to MSS-SP-67.
 - c. Dead end pressure rating shall be 150 psi with no downstream flange/piping attached.
 - d. For valves 6" and smaller, provide 10-position lever actuators with locking devices. For valves 8" and larger, provide rotary hand wheel operators with adjustable position stop and position indicators. Size hand wheel operators with no higher than 40 lb rim pull at full valve pressure rating.
 - e. External disc-to-stem connections using screws or pins are not allowed.
 - f. Valve necks shall be of sufficient length to allow for insulation where insulation is specified. Wheel shaft shall be sufficient length so wheel does not touch insulation.
 - g. Provide full lug type valves permitting removal of down stream piping while using valve for system shut-off.
 - h. Furnish valves used for balancing with adjustable memory stops.
 - i. .

H. Butterfly Valves (High Performance):

1. Manufacturers: DeZurik Type BHP, Xomox, Jamesbury, Bray Series 40, or Posi-Seal
2. Carbon steel or stainless steel body, ANSI Class 150 design rated for 275 psi at 100°F, bidirectional bubble-tight shut off at 275 psi, threaded lug type, upper and lower body bearings with thrust bearings, one piece single or double offset shaft of 316 stainless steel and centerless ground and polished to minimize bearing and packing wear, PTFE seats, PTFE adjustable V-ring packing, capable of service in temperature ranges of -100 to 300°F, 316 stainless steel discs and totally enclosed, factory lubed, handwheel rotary actuator with external disc position indication.
3. Dead end pressure rating shall be 275 psi without downstream flanging.

I. Water Pressure Regulating Valves:

1. Manufacturers: Thrush, Watts, Cash-Acme, Taco, or B & G
2. Brass or bronze body, spring and diaphragm operated, pressure adjustable with check valve and inlet strainer and designed for maximum working pressure of 125 psig and maximum operating temperature of 160°F.

J. Lockshield Valves:

1. Ball valves as specified above with locking handles for padlocking in open or closed position.

K. Drain Valves:

1. Ball valve as specified above with threaded hose adapter and cap. Provide 3/4" minimum drain valve for piping larger than 1/2", except strainer blowdown valves shall be blowdown connection size. Provide 1/2" drain valve for 1/2" piping. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.

L. Pressure Compensating Flow Control Valves:

1. All metal construction, factory set to automatically maintain flow rate within plus/minus 5% accuracy over operating pressure differential range of at least 14 times minimum required for control, self-contained spring loaded perforated cartridge control mechanism, passivated stainless steel internal working parts, rated for 200 psi pressure at 250°F.
2. Valves 2" and under to have threaded ends with ground joint union; 2-1/2" and larger to have flanged ends.
3. Each automatic flow control valve to have pressure tappings with quick disconnect fittings suitable for use with portable measuring instrument specified, to verify pressure differential across flow control orifice.
4. Certified performance data based on independent laboratory tests to be available.
5. Manufacturers: Griswold, Autoflow or Dole
6. Furnish to Owner portable pressure-temperature measuring kit consisting of 2 pressure gauges with 4-1/2" dial, air bleed device, hoses, quick-connect fittings, protected thermometer, instructions and carrying case. Kit to be used to read pressure drop across flow control orifice and temperature at that point.

2.3 WATER SYSTEM VALVES – CHILLED WATER/MEDIUM TEMPERATURE CHILLED WATER

A. General:

1. Valves 2" and smaller in steel piping shall have threaded ends.
2. Valves 2" and smaller in copper piping shall have solder ends.
3. Provide valve stem extensions with sufficient length to allow for insulation where insulation is specified.
4. All chilled water valves to be rated for 250 psig WOG working pressure.
5. Valves for 3"-4": Resilient seated, lug style, butterfly valves with bubble tight bi-directional shutoff at 250 psig, ductile iron body with locking handle, lever operators, 150 ANSI bolt pattern.
6. Valves for 6" and up: Resilient seated, lug style, butterfly valves with bubble tight bi-directional shutoff at 250 psig, ductile iron body with gear operator and hand wheels, 150 ANSI bolt pattern.

B. Ball Valves:

1. 2" and Smaller: ASTM B584 bronze body, chrome plated brass/bronze or stainless steel ball, full port for 3/4" and smaller and conventional port for 1" and larger, Teflon seat rings, blowout-proof stem, 2-piece construction, 600 psi WOG, 150 psi SWP, Nibco Fig. T(S)-580-70, Apollo No. 70, Watts, Milwaukee BA-150, Hammond, Kitz or Anvil

C. Spring Loaded Check Valves:

1. 2" and Smaller: bronze or iron body, Class 125 (250 psi WOG), Nibco Figure T(S)-480-Y, Mueller Figure 303-BP or Metraflex No. BSN
2. 2-1/2" and Larger: cast iron or ductile iron body, flanged or wafer type, 302/304 or 316 stainless steel spring, aluminum bronze, carbon steel or ductile iron totally encapsulated in EPDM disc, Buna-N or electroless nickel plated seat, Class 250 (250 psi WOG), Nibco Figure

F-960 or W-960, Milwaukee 1800 or 1400, Metraflex No. 700, Mueller Sure Check Model No. 74, or Crane Duo-check II

3. For valves 8" and larger, provide lifting lugs or threaded holes for lifting eye bolts.

D. Shut-Off Valves:

1. 2" and Smaller: ball valves as specified in this Section
2. 2-1/2" and Larger: butterfly valves as specified in this Section

E. Balancing Valves:

1. 2" and Smaller: calibrated balancing valves:
 - a. Variable orifice with multiple turn valve type as manufactured by Armstrong Series CBV or ABV, Tour & Andersson (Victaulic) Series 786 or 787, NIBCO 1709 or 1710, or fixed orifice with ball valve type as manufactured by Flow Design Inc. (FDI), Presco, Gerand, Nexus, HCl or Taco. Bronze or brass body, 250 psi maximum working pressure, 250°F maximum operating temperature. Furnish valve with adjustable memory stop and quick disconnect taps with built-in check valve for pressure differential measurement, integral valve setting index and memory locking device.
 - b. Valves shall measure down to 0.3 gpm with accuracy of $\pm 5\%$.
 - c. Valves shall be leak-tight at full rated working pressure.
 - d. Unless otherwise indicated, size balancing valves so that at design flow rate, pressure drop across balancing valve with valve approximately 50% open will be at minimum 25% of reading range of meter used for balancing.
2. 2-1/2" and Larger: Armstrong Series CBV or Tour and Anderson (Victaulic) Series 788, ductile iron body, ASME/ANSI B16.42 Class 150 flange, 250 psi maximum working pressure, 250°F maximum operating temperature. Fixed orifice with ball valve or butterfly valve as manufactured by FDI, Presco or Gerand, Class 150 flange, 225 psi maximum working pressure, 250°F maximum operating temperature will be acceptable up to 4" size. Butterfly valves, as specified in this Section, together with averaging Pitot tube flow sensors, as specified in Section 23 2120 - Piping Specialties, under Flow Sensors and Meters between check valve and butterfly valve may be used when sizes for Armstrong or T/A valves are not available. Furnish butterfly valves with adjustable memory stops to limit return of valves to preset open position after shut-off.
3. Furnish portable meter kit within durable case similar to Gerand Model "R". Furnish meter with minimum 4-1/2" diameter aluminum or brass body/brass internals with reading range of either 0" to 50" or 0" to 100" water column differential as appropriate, 200°F maximum temperature, 300 psi working pressure. Meter accuracy shall be $\pm 2\%$ full scale. Provide in kit: equalizing valves, 10 ft purge hose and size devices specified. Meter shall become property of Owner.
4. Contractor shall furnish meter for calibration and shall retain meter after final calibration.

F. Terminal Unit Valve Assembly

1. Terminal unit valve assembly may be used instead of individual valve and other components, provided each valve and component meets specified requirements.
2. Victaulic, Nexus, Griswold, HCl or FDI are acceptable.
3. Inlet assembly shall be combination of isolation ball valve, y-strainer, union, and PT test port similar to Victaulic Coil Pack Series 78 Y, and outlet assembly shall be combination of isolation ball valve, union, PT test ports and balancing valve similar to Victaulic Coil Pack Series 78K and 784.

G. Butterfly Valves:

1. 2-1/2" and Larger:

- a. Manufacturers: DeZurik, Keystone, Nibco, Milwaukee, or Bray
 - b. Ductile iron body, stainless steel shaft, aluminum-bronze disc, or Nylon 11 coated ductile iron disc, upper thrust bearing, EPDM resilient seat, rated at 250 psi bidirectional shut-off pressure, suitable for continuous operation at temperature up to 225°F, compatible to ANSI B16.1 Class 150 flange standards, conforming to MSS-SP-67.
 - c. Dead end pressure rating shall be 150 psi with no downstream flange/piping attached.
 - d. For valves 6" and smaller, provide 10-position lever actuators with locking devices. For valves 8" and larger, provide rotary hand wheel operators with adjustable position stop and position indicators. Size hand wheel operators with no higher than 40 lb rim pull at full valve pressure rating.
 - e. External disc-to-stem connections using screws or pins are not allowed.
 - f. Valve necks shall be of sufficient length to allow for insulation where insulation is specified. Wheel shaft shall be sufficient length so wheel does not touch insulation.
 - g. Provide full lug type valves permitting removal of down stream piping while using valve for system shut-off.
 - h. Furnish valves used for balancing with adjustable memory stops.
- H. Butterfly Valves (High Performance):
1. Manufacturers: DeZurik Type BHP, Xomox, Jamesbury, Bray Series 40, or Posi-Seal
 2. Carbon steel or stainless steel body, ANSI Class 150 design rated for 275 psi at 100°F, bidirectional bubble-tight shut off at 275 psi, threaded lug type, upper and lower body bearings with thrust bearings, one piece single or double offset shaft of 316 stainless steel and centerless ground and polished to minimize bearing and packing wear, PTFE seats, PTFE adjustable V-ring packing, capable of service in temperature ranges of -100 to 300°F, 316 stainless steel discs and totally enclosed, factory lubed, handwheel rotary actuator with external disc position indication.
 3. Dead end pressure rating shall be 275 psi without downstream flanging.
- I. Water Pressure Regulating Valves:
1. Manufacturers: Thrush, Watts, Cash-Acme, Taco, or B & G
 2. Brass or bronze body, spring and diaphragm operated, pressure adjustable with check valve and inlet strainer and designed for maximum working pressure of 250 psig and maximum operating temperature of 160°F.
- J. Lockshield Valves:
1. Ball valves as specified above with locking handles for padlocking in open or closed position.
- K. Drain Valves:
1. Ball valve as specified above with threaded hose adapter and cap. Provide 3/4" minimum drain valve for piping larger than 1/2", except strainer blowdown valves shall be blowdown connection size. Provide 1/2" drain valve for 1/2" piping. If 3-piece ball valves are specified, use 2-piece ball valves with same construction.
- L. Pressure Compensating Flow Control Valves:
1. All metal construction, factory set to automatically maintain flow rate within plus/minus 5% accuracy over operating pressure differential range of at least 14 times minimum required for control, self-contained spring loaded perforated cartridge control mechanism, passivated stainless steel internal working parts, rated for 250 psi pressure at 250°F.

2. Valves 2" and under to have threaded ends with ground joint union; 2-1/2" and larger to have flanged ends.
3. Each automatic flow control valve to have pressure tappings with quick disconnect fittings suitable for use with portable measuring instrument specified, to verify pressure differential across flow control orifice.
4. Certified performance data based on independent laboratory tests to be available.
5. Manufacturers: Griswold, Autoflow or Dole
6. Furnish to Owner portable pressure-temperature measuring kit consisting of 2 pressure gauges with 4-1/2" dial, air bleed device, hoses, quick-connect fittings, protected thermometer, instructions and carrying case. Kit to be used to read pressure drop across flow control orifice and temperature at that point.

2.4 LOW PRESSURE STEAM AND CONDENSATE SYSTEM VALVES (15 PSIG AND LOWER)

A. Gate Valves:

1. 2" and Smaller: ASTM B62, bronze body, bronze trim, threaded, solid wedge, rising stem, union bonnet, malleable iron hand wheel, Class 150 (150 psi WP steam), conforming to MSS SP-80, Nibco Fig. T-134
 - a. For steam condensate system, ball valves may be used.
 - 1). ASTM B584 bronze body, threaded, 316 stainless steel ball, full port, Teflon seat rings, blowout-proof stem, two-piece construction, 150 psi SWP, Nibco Fig. T-585-70-66, Appollo, Watts, Milwaukee or Hammond
2. 2-1/2" and Larger: iron body, bronze trim, OS&Y, bolted bonnet, solid wedge, flanged, Class 150 (125 psi WP steam), conforming to MSS SP-70, Nibco Fig. F-617-0.

B. Globe Valves:

1. 2" and Smaller: ASTM B62, bronze body, bronze trim, threaded, renewable TFE seat disc, union bonnet, malleable iron handwheel, Class 150 (150 psi WP steam), conforming to MSS SP-80, Nibco Fig. T-235
2. 2-1/2" and Larger: iron body, bronze trim, OS&Y, flanged, bolted bonnet, renewable bronze seat and disc, Class 150 (125 psi WP steam), conforming to MSS SP-85, Nibco Fig. F-718

C. Swing Check Valves:

1. 2" and Smaller: ASTM B62, bronze body, threaded, regrinding, Y-pattern swing type, renewable TFE seat disc, Class 150 (150 psi WP steam), conforming to MSS SP-80, Nibco Fig. T-433
2. 2-1/2" and Larger: iron body, bronze or brass trim, renewable seat and disc, Class 150 (125 psi WP steam), conforming to MSS SP-71, Nibco Fig. F-918

D. Shut-Off Valves: Use gate valves as specified above.

E. Drain Valves:

1. Gate valve as specified above with threaded hose adapter and cap. Provide 3/4" minimum drain valve size except strainer blowdown valves to be blowdown connection size.

2.5 HIGH PRESSURE STEAM & CONDENSATE SYSTEM VALVES (16PSIG THROUGH 200 PSIG)

A. Gate Valves:

1. 2" and Smaller: ASTM B61, bronze body, threaded, rising stem, solid bronze wedge, union bonnet, stainless steel seat rings, malleable iron handwheel, Class 300 (300 psi WP steam), conforming to MSS SP-80, *Powell Fig. No. 2377*

2. 2-1/2" and Larger: ASTM A216, WCB, steel body, OS&Y, stainless steel or 13% chromium hard faced wedge and seat ring, flanged, bolted bonnet, Class 300, (300 psi WP at 500 degrees F), conforming to ASME B16.5, B16.10 and B16.34, Stockham Figure 30-OF, Powell Fig. 3003N, Crane 33, Milwaukee 3050, Velan Fig. 1064C, or Williams 30F
- B. Globe Valves:
1. 2" and Smaller: ASTM B61, bronze body, threaded, union bonnet, stainless steel plug disc and seat rings, malleable iron handwheel, Class 300 (300 psi WP steam), conforming to MSS SP-80, Powell Fig. No. 2612
 2. 2-1/2" and Larger: ASTM A216, WCB, steel body, stainless steel disc and seat rings, flanged, bolted bonnet, Class 300, (300 psi WP at 500 degrees F), conforming to ASME B16.5, B16.10 and B16.34, Stockham Fig. 30-GSF, Powell Fig. 3031, Crane, Milwaukee 3060, Velan Fig. 1074C, or Williams 302
- C. Swing Check Valves:
1. 2" and Smaller: ASTM B61, bronze body, threaded, regrinding, renewable TFE or cast bronze seat disc, Y pattern, Class 300 (300 psi WP steam), conforming to MSS SP-80, Nibco Fig. T-473.
 2. 2-1/2" and Larger: ASTM A216, WCB, steel body, stainless steel seats and discs, bolted bonnet, Class 300, (300 psi WP at 500 degrees F), conforming to ASME B16.5, B16.10 and B16.34, Stockham Fig. 30-SF, Powell Fig. 3061, Crane, Milwaukee 3070, Velan Fig. 1114C, or Williams 301
- D. Shut-Off Valves:
1. Use gate valves as specified above.
- E. Drain Valves:
1. Gate valve as specified above with hose thread adapter and cap. Provide 3/4" minimum drain valve size, except strainer blowdown valves shall be blowdown connection size.
- F. Butterfly Valves:
1. Manufacturers: Saunders MS, Vanessa, Adams HTK or Bray Tri-Lok Series
 2. Valves shall be triple offset design and constructed of all metal construction with no elastomers or polymers used for sealing. Valves shall have stainless steel resilient seal ring on disc edge and machined seat in valve body. Valves shall meet API 598 shut-off rate of zero leakage, bi-directional.
 3. Valves shall be double flanged, ANSI Class 300 for steam pressure up to 100 psig and Class 300 for steam pressure 101 psig through 200 psig. Valve body shall be one piece cast double flanged, welded bodies not permitted.
 4. Body shall be carbon steel ASTM A216WCB. Disc shall be conical carbon steel ASTM 216WCB nickel-plated or phosphate coated. Sealing surfaces shall be stainless steel laminated and seal ring and seat have matching conical shape and shall be suitable for application and recommended by manufacturer. Valve disc shall be connected to the stem by an internal splined connection or shaft to disc connections shall be with "keys" top and bottom and shall not be rigidly pinned so as to allow shaft and disc to properly move with thermal expansion and continue to provide ease of operation and zero leakage.. Disc shall have one hub and stem shall not be exposed to the flow.
 5. Stem shall be one-piece design. Stem shall be stainless steel and shall be provided with a position indicator. Stem shall be provided with blow-out prevention ring outside of the pressure boundary.

6. Bearings shall be designed to minimize the load and wear. Bearings shall include replaceable graphite seal.
7. Valve shall be tested in accordance with API 598 and have zero leakage.
8. Manual gear actuators shall be sized for installation of valve in non-preferred flow direction. Maximum rim pull for valve operation shall not exceed 100 pounds.

2.6 WATER PRESSURE RELIEF VALVES

- A. Manufacturers: Kunkle, Consolidated, Thrush, Watts, Cash-Acme, Lonergan, Keckley, or B & G. Iron or bronze body, direct pressure actuated, Teflon seat, stainless steel stem and spring, and suitable for maximum working pressure of 125 psig at 240°F.
- B. Valves to conform to State Requirements and have ASME Stamps.

2.7 STEAM SAFETY VALVES

- A. Manufacturers: Kunkle, Consolidated, Spirax/Sarco, Agco, or Farris equal to manufacturer's model scheduled. Copper alloy or cast iron body, copper alloy disc, aluminum coated steel or stainless steel spring located in housing, with ASME stamp and test lever. Unless otherwise indicated, scheduled capacities are for saturated steam in pounds per hour, 90% basis, 10% accumulation in accordance with ASME Codes for unfired pressure vessels. Inlet and outlet connections may be female pipe threads or flanged. Unless otherwise indicated, provide drip pan elbow equal to Kunkle Fig. 299 at each valve.
- B. Valves to conform to State Requirements.

2.8 GAUGE VALVES

- A. Unless otherwise indicated, gauge valves for steam, steam condensate and feedwater services shall be gate valves. Gauge valves for all other services shall be needle valves, brass body, 2000 psig, 300°F, similar to Trerice Model 735. Gauge valve size shall match gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings.

2.9 PRESSURE EQUALIZING/WARM UP BYPASS VALVES

- A. Use 3/4" globe valve for main valve (gate valve) up to 8" and 1" globe valve for main valve (gate valve) 10" and larger. Valves shall be as specified in each system. Globe valve may be factory integrated to main valve.

2.10 SELF-CONTAINED THERMOSTATIC CONTROL VALVES

- A. Manufacturers: Danfoss or Braukmann equal to Danfoss Model RA. Valve assembly to be capable of maximum working pressure of 150 psi hot water or 15 psi steam, maximum working temperature of 248°F and maximum differential pressure of 17 psi.
- B. Valve body to be made of cast brass and to have interchangeable threaded type tail piece. Valves to be furnished with manual adjustment to enable use during final construction period without installing control unit.
- C. Valve to be furnished with stainless steel spindle riding against o-ring within packing gland. This o-ring packing gland to be replaceable with standard tools while system is in operation and without any need for isolation valves.
- D. Control unit to be capable of being locked or limited and be adjustable from 45°F to 85°F and incorporate sensor and bellows. Bellows to be balanced by adjustment spring.

- E. Control unit accuracy to be within $\pm 1^{\circ}\text{F}$ and to be fail-safe such that should failure occur, valve body will automatically open to protect against freezing.
- F. Unless otherwise noted, valves to be 3/4" angle, straight or side mount as required.
- G. Sensor to be built-in type.
- H. Provide remote sensing bulb mounted underneath fin tube radiation element.
- I. Provide remote wall mounted control thermostat. Install capillary tube in wall.

2.11 CHAIN WHEEL OPERATORS

- A. Similar to Babbitt cast iron or ductile iron adjustable sprocket rims and chain guides. Use galvanized or brass chain and chain closure links to form continuous loop of chain at each operator.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install valves as shown on plans, details and according to manufacturer's installation recommendations.
- B. After piping systems have been pressure tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust, replace packing or replace valves to stop leaks.
- C. Install control valves furnished under Control Systems. Provide reducing fittings as required.
- D. Refer to Section 23 2116, Part 3 for reducing fittings requirement for valves smaller than pipe size.
- E. Provide chain operators for manually operated valves 4" and larger, located more than 8 ft above equipment room floor.

3.2 SHUT-OFF VALVES

- A. Provide shut-off valves at all equipment, at riser take-offs at each floor, and at each automatic valve for servicing.
- B. Install steam system shut-off valves in horizontal piping. Shut-off valves are not allowed in vertical piping.

3.3 BALANCING VALVES

- A. Provide balancing valves where indicated on drawings and as required for complete balancing of water systems.
- B. Provide straight inlet and outlet pipe length in accordance with manufacturer's recommendation.
- C. For buildings with multiple stories, provide balancing valve in return line at riser take-offs at each floor. Provide shut off valve in supply line at each riser take-off.

3.4 GAUGE VALVES

- A. Provide gauge valves at each pressure gauge as shown and at each pressure tapping where pressure sensing tubing is connected.

3.5 DRAIN VALVES

- A. Provide drain valves at all low points of piping systems for complete drainage of systems.

3.6 WATER PRESSURE REGULATING VALVES

- A. Set valves for pressure required or as scheduled.

3.7 WATER RELIEF VALVES

- A. Unless otherwise indicated, provide one relief valve in each closed water system in the pump inlet piping.

3.8 SPRING LOADED CHECK VALVES

- A. Provide spring loaded check valve in each pump discharge line.

3.9 SWING CHECK VALVES

- A. Provide swing check valves at steam condensate lines if lifted at outlet of traps. Install check valve between trap and gate valve.

3.10 COMBINATION SHUT-OFF, CHECK AND BALANCING VALVES

- A. Contractor may provide combination shut-off, check and balancing valve in lieu of providing separate shut-off valve, check valve and balancing valve in pump discharge line.

3.11 WARM UP(PRESSURE EQUALIZING) BYPASS VALVES

- A. Provide bypass valves on valves in the following locations:
 - 1. Steam shut-off valves (gate valves) 4" and larger on steam pressure greater than 60 psig for supervised warm-up.

3.12 AUTOMATIC NON-RETURN STOP VALVES

- A. Provide automatic non-return stop valve in each steam boiler outlet before header in high pressure steam systems.

3.13 STEAM PRESSURE REGULATING VALVES

- A. Provide gate valve and steam strainer on inlet and gate valve on discharge of each valve.
- B. Provide pressure gauges to meet requirements of pressure reducing valve manufacturer.
- C. Provide reducing fittings on both sides of reducing valve as detailed.
- D. Air piping and associated air valves to each air loading valve shall be provided under Section 23 0901 - Control Systems, and 23 0993 - Control Sequences.

3.14 STEAM SAFETY VALVES

- A. Provide steam safety valves after steam pressure regulating stations and at pressure vessels.
- B. Provide vent to outside of building.
- C. If drip pan elbow is specified or indicated, install drip pan elbow at base of vertical discharge pipe and as close to safety valve outlet as possible. Support pipe to keep weight of pipe and

accessories from resting on safety valve or drip pan elbow. Run drain lines from drip pan elbow to nearest drain point.

- D. Pitch horizontal discharge pipes minimum 1/8" per foot in direction of flow, and provide for complete condensate drainage through drip legs and thermostatic traps at points in discharge pipe where condensate will collect. Pipe outlet of thermostatic trap to nearest drain point.
- E. Pipe safety valve tapped body drains to nearest drain point.
- F. If "closed" connection to safety valve is indicated (directly hard piped or safety valve connected to discharge pipe through flexible connection) anchor discharge pipe immediately at outlet of safety valve, or immediately downstream of flexible connection. Support pipe to keep weight of pipe and accessories from resting on safety valve.

END OF SECTION

SECTION 23 2120 PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 23 0594 - Water Systems Test Adjust Balance
- B. Section 23 0903 - Control Instrumentation (Temperature and Pressure Sensing Requirements)
- C. Section 23 2118 - Valves

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 REFERENCE STANDARDS

- A. Metal bellows expansion joints shall be constructed and applied in accordance with "Standards of the Expansion Joint Manufacturer's Association", 8th Edition, 2003.

1.4 SUBMITTALS

- A. Shop Drawings for all items in this Section including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the Documents
 - 3. Materials of construction
 - 4. Dimensional data
 - 5. Capacities/ranges
 - 6. Temperature/pressure ratings
 - 7. Pressure drop
 - 8. Expansion joint schedule indicating joint tag no., system, proximity to rotating or reciprocating equipment, required movement in all planes, service pressure, test pressure, service temperature, fluid velocity and cycles to failure (both thermally and seismically, if applicable).
 - 9. All other appropriate data.
- B. LEED Submittal
 - 1. Product Data for IEQ Credit 4.1: For adhesives and sealants, including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Unless otherwise specified, select devices for highest pressures and temperatures existing in respective systems in accordance with ANSI Specifications.
- B. Piping specialties in copper piping shall have bronze or brass body with solder ends.

2.2 THERMOMETERS

- A. Manufacturers: Taylor, Trerice, Weksler, Miljoco, Winters, or Weiss
- B. Pipeline mounted thermometers: 9" scale cast aluminum case and frame, clear acrylic plastic window front, permanently stabilized glass tube with mercury free indicating fluid, adjustable angle stem, extended neck suitable for insulated piping as required, and compatible with sockets as specified herein.
- C. Panel or remote mounted thermometers: vapor actuated dial type with remote bulb, 4-1/2" minimum diameter cast metal casing with double front. Sensing bulbs shall be of length to suit pipe diameter with extended necks as required for insulated piping, suitable for insertion in separable brass sockets as specified herein.
- D. Duct type thermometers: dial type with minimum dial size of 4-1/2" and maximum graduations of 2°F, complete with swivel mounting arrangement to permit up to 45° rotation for easy reading.
- E. Range of thermometers shall be:

<u>Service</u>	<u>Scale Range</u>	<u>Increment</u>
Chilled Water	0°F to 100°F	1°F
Condenser Water	30°F to 130°F	1°F
Heating Hot Water	30°F to 240°F	2°F
Steam Condensate	30°F to 300°F	2°F

- F. Thermometers by temperature control manufacturer meeting above Specification will be acceptable.

2.3 THERMOWELLS AND TEST WELLS

- A. Brass construction for carbon steel piping with threaded connections suitable for thermometer bulbs and control sensing devices, well length suitable for pipe diameter with extended neck as required to suit pipe insulation. Trerice 5550 Series or approved equal.
- B. For test wells for stainless steel piping, use same material as piping.

2.4 PRESSURE GAUGES

- A. Manufacturers: Ashcroft, U.S. Gauge, Marsh, Trerice, Miljoco, Marshalltown, Weksler, Winters or Weiss equal to Trerice 450600 Series
- B. Minimum 4-1/2" diameter die cast aluminum case, glass or acrylic plastic window, phosphor bronze bourdon tube with bronze bushed movement, recalibration from front of gauge dial and 1/4" NPT forged brass socket.
- C. Gauge accuracy shall meet ANSI B40.100 Grade 1A (±1% full scale).
- D. Reading range of gauges shall be:

<u>Service</u>	<u>Scale Range</u>
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Chilled Water

0 to 100 psig

Heating Hot Water	0 to 100 psig
Low Pressure Steam	30" mercury vacuum to 30 psig
High Pressure Steam	0 to 150 psig for maximum steam pressure of 80 psig.
High Pressure Steam	0 to 250 psig for maximum steam pressure of 180 psig.

E. Pressure Snubbers:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116 - Pipe and Pipe Fittings, 1000 psig WP. Brass for carbon steel pipe or copper pipe. Stainless steel for stainless steel pipe.

F. Coil Syphons:

1. 1/4" or 1/2" size, matching gauge pipe size as specified in Section 23 2116, 500 psig WP. Material shall match gauge pipe material.

2.5 PRESSURE/TEMPERATURE TEST STATIONS

- A. Pete's plugs made by Peterson Equipment Company, Sisco, Super Seal by Flow Design Inc. (FDI), or approved equal.
- B. Test plugs shall be 1/4" or 1/2" NPT, brass body and cap, 1-1/2" length for non-insulated pipe and 3" length for insulated pipe, with Nordel self-closing valve cores, rated at 500 psig at 275°F, and shall receive either temperature or pressure probe with 1/8" OD.
- C. Furnish portable test kit within durable case containing the following:
 1. A compound pressure gauge, 3-1/2" dial, 30" Hg – 100 psi, field calibration screw, surge protector and stainless steel gauge adapter with 1/8" diameter probe (2% accuracy of mid range).
 2. Two pocket testing thermometers, 1-3/4" dial, 5" long stainless steel stem, 0 - 220°F and 25 - 125°F ranges with external calibration (1% accuracy of entire scale).

2.6 PIPE EXPANSION DEVICES

- A. Expansion Loops:
 1. Size expansion loops including L-bends and Z-bends as indicated on drawings or as scheduled.
 2. Size expansion loops including L-bends and Z-bends to allow adequate expansion of main straight runs of system within stress limits specified in ANSI B31.1.
- B. Expansion Compensators:
 1. Manufacturers: Metraflex, Vibration Mountings and Controls Inc., Hyspan, Expansion Joint Systems, or Flexonics
 2. Compensators shall be constructed of 2 ply stainless steel bellows with carbon steel shrouds and end fittings.
 3. Furnish compensators with internal guides full length of bellows travel and positive internal anti-torque devices to prevent twist or torque during installation. Furnish properly located

positioning clips to insure installation at correct end-to-end dimension allowing full rated traverse.

4. Expansion compensators shall be suitable for system pressure and temperature.
- C. Flexible Expansion Loops:
1. Manufacturers: Metraflex
 2. Flexible expansion loops shall be Metraflex Metraloop consisting of 2 flexible sections of hose and braid, two 90° elbows, and a 180° return, with factory supplied, center support nut located at bottom of 180° return and drain/air release plug.
 3. Flexible loops shall impart no thrust loads to system support anchors or building structure.
 4. Unless otherwise indicated, material of construction, end fitting type and pressure ratings shall be consistent with pipe material, pipe connection fittings and pressure rating as specified in specification Section 23 2116 - Pipe and Pipe Fittings.
 5. Hose and braid material shall be 316L.
- D. Flexible Ball Joints:
1. Manufacturers: Hyspan, Barco or Advanced Thermal Systems
 2. Carbon steel or stainless steel construction as appropriate for service intended, flanged end connections, and constructed in accordance with Section VIII of ASME Code and ANSI B31.1.
 3. Ball joints shall be designed for injection of packing under full line pressure with recharge cylinders on casings.
 4. Injectable packing shall be self-lubricating flake, graphite pellets.
 5. Ball sphere shall be plated consisting of 1 mil of hard chrome applied over 1 mil of crack-free chrome.
 6. Joints shall allow 300° rotation and 15° minimum total angular flex.
 7. Joints shall be designed for working temperature and pressure suitable for application, but not less than 150 psig WP, and continuous operating temperature of 525°F.
- E. Expansion Joints (Bellows-type):
1. Manufacturers: Flexonics, Metraflex, Expansion Joint Systems, Microflex, American BOA, or Hyspan
 2. Expansion joints shall be flanged, packless, constructed of 304 stainless steel bellows and carbon steel fittings.
 3. Expansion joints shall be rated for working temperature and pressure of the system, but not less than 150 psig WP.
 4. Furnish joints with limit stops or tie rods to prevent over traversing.
 5. Furnish external sheet metal shrouds on all expansion joints required to be insulated. Shrouds shall be removable for field inspection of joints. Refer to Section 20 0700 - Mechanical Systems Insulation for insulation requirement.
 6. Furnish joints with internal sleeves (liners) constructed of 304 stainless steel with sufficient clearance between bellows and sleeve to permit full rated rotational and lateral movement. Provide drain holes for sleeves as required.
- F. Steam Safety Valve Connectors:
1. Manufacturers: Senior Flexonics Hyspan or approved equal
 2. Carbon steel body with multi-ply Type 321 or Type 316L stainless steel bellows, designed to 150 psig at 500°F, with movements of 2" axial deflection and 1" lateral deflection, full length integral pipe liner, vent pipe sized outlet, with 1/2" NPT drain port and removable positioning

devices with orientation markings. Equal to Senior Flexonics Pathway "Series SVC" or Hyspan Series 3500 SRV.

3. .

2.7 PIPELINE STRAINERS

A. Manufacturers: Metraflex, Mueller Steam Specialty, Hoffman, Eaton (formally Hayward), Sarco, Keckley, Armstrong, Wheatley, Conbraco or Streamflo

B. Liquid System:

1. 2" and Smaller: full pipeline size, Y-type, with removable screen caps, cast iron, Class 250 (400 psi/150°F WOG), threaded ends for carbon steel piping and bronze, Class 150 (200 psi/150°F WOG),,, solder ends for copper piping. Screen caps shall have threaded blowdown connection.
2. 2-1/2" and Larger: full pipeline size, Y-type, Class 125(200 psi/150°F WOG), cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.
3. Liquid Service Screens: stainless steel with screen perforation as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation, provide per manufacturer requirements. Maximum pressure drop shall be 4 ft WG through clean strainer.

<u>Pipe Size</u>	<u>Closed System</u>	<u>Open System</u>
2" and smaller	1/32" (20 mesh)	1/8"
2-1/2" to 4"	1/16"	1/8"
5" and over	1/8"	1/8"

C. Steam and Condensate System (through 100 psig):

1. 2" and Smaller: full pipeline size, Y-type, Class 250, cast iron, threaded ends with removable screen caps. Screen caps shall have threaded blowdown connection.
2. 2-1/2" and Larger: full pipeline size, Y-type, Class 125, cast iron, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.

D. Steam and Condensate System (101 psig through 200 psig):

1. 2" and Smaller: full pipeline size, Y-type, Class 300, cast iron, threaded ends with removable screen caps. Screen caps to have threaded blowdown connection.
2. 2-1/2" and Larger: full pipeline size, Y-type, Class 300, steel, flanged ends. Furnish strainer with bolted screen retainer and off-center blowdown connection.

E. Steam Service Screens: stainless steel for low pressure and monel for high pressure with screen perforation size as indicated below. For strainers serving equipment where manufacturer requires specific screen perforation, provide per manufacturer requirements. Net area of screen shall be at least 4 times that of connected pipe.

<u>Pipe Size</u>	<u>Perforation Size</u>
2" and smaller	1/50" (30 mesh)
2-1/2" to 10"	3/64"(.045")
12" and over	1/16"(.062")

2.8 STEAM TRAPS

- A. Manufacturers: Armstrong, Sarco, Hoffman, or Watts
- B. Trap bodies shall be suitable for minimum 1.5 times system pressure, but not less than 125 psig.
- C. Traps shall have threaded end connections.
- D. Unless otherwise indicated, determine trap capacity with the following safety factor, differential pressure and steam pressure at apparatus inlet. Minimum trap size (pipe connection size) shall be 3/4" for all types.
 1. Apply safety factor to maximum steam rate of apparatus served and at saturated steam temperature.
 2. 0-15 psig steam:
 - a. Safety factor of 2:1 at 1/2 psi pressure differential
 3. 16-30 psig steam:
 - a. Safety factor of 2:1 at 2 psi pressure differential
 4. Above 30 psig steam:
 - a. Safety factor of 3:1 at 1/2 of maximum pressure differential across trap
- E. Size main drip, end-of-main or drip-and-rise traps with 2:1 safety factor at full differential pressure for supervised warm-up load, but not less than 250 lb per hour and not smaller than 3/4" size.
- F. Where 2 traps are shown in parallel, each trap shall have full design capacity of equipment without safety factor.
- G. Thermostatic Traps:
 1. Cast brass body with removable cover, renewable stainless steel seats, plungers and diaphragm or bellows.
- H. Float and Thermostatic Traps:
 1. Cast iron or semi-steel body with removable cover, stainless steel float, diaphragm or bellows thermostatic operator, and stainless steel valve mechanism.
- I. Inverted Bucket Traps:
 1. Cast iron or semi-steel body with removable cover, stainless steel bucket, and stainless steel valve mechanism assembly.

2.9 AIR VENTS

- A. Manual Air Vents:
 1. Manufacturers: Bell & Gossett Model 4V, 125 psig at 210°F or approved equal. Use 1/2" ball valve for main pipes.
- B. Automatic Air Vents:
 1. Manufacturers: Amtrol, Watson McDaniel, B&G, or Hoffman

2. Metal construction, non-corrosive working parts, 150 psig WP at 240°F
3. Normal capacity vent shall be similar to B&G Model 87
4. High capacity vent shall be float actuated and shall have minimum air elimination rate of 10 cfm at 100 psig, similar to B&G Model 107A.

C. Thermostatic Air Vents:

1. Balanced pressure type, cast bronze body, bronze bellows caged in stainless steel, stainless steel valve and seat, 1/2" threaded connection, 125 psig WSP, equal to Armstrong Model TV-2.

2.10 VACUUM RELIEF/BREAKERS

- A. Kadant Johnson Series VB-8 with brass body, stainless steel ball, EPR seat, stainless steel spring, suitable for pressures to 300 psig at 365°F, or Sarco Model VB-14.

2.11 STRAIGHTENING VANES

- A. Manufacturers: Daniel Industries, Inc., Houston, Texas or approved equal
- B. Straightening vane assembly shall consist of series of carbon steel pipes firmly welded together and to line size pipe. Furnish vanes with class 150 psi flanges for insertion into piping system.

2.12 STEAM VENT EXHAUST HEADS

- A. Manufacturers: Eaton Filtration, Bryan Steam, Watson McDaniel, or Penn Separator
- B. Steam exhaust head shall be cyclone design for vertical venting to atmosphere. Unit shall have vortex containment plate feature to prevent re-entrainment of liquid and shall be 99% effective at removing entrained liquid and solid particles over 10 microns in size. Exhaust head shall be constructed of cast iron or stainless steel and available in FNPT for sizes 2" and smaller and Class 125 flange for sizes 2-1/2" and larger.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install piping specialties as indicated on plans, details and according to manufacturer's recommendations.

3.2 THERMOMETERS

- A. Install thermometers in thermowells in locations indicated.

3.3 THERMOMETER TEST WELLS

- A. Install test wells in locations as shown and at each point where temperature-sensing device is required under Control Systems.

3.4 PRESSURE GAUGES

- A. Install gauges for services other than steam with pressure snubbers and gauge valves.
- B. Install gauges for steam service with coil syphons and gauge valves.

3.5 PRESSURE GAUGE TAPPING

- A. Install tapplings with gauge valves at each point where sensing device is required under Control Systems and at gauge locations as shown.
- B. Use threadolets or tee fittings to mount gauge tapplings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.6 PRESSURE/TEMPERATURE TEST STATIONS

- A. Pete's plug may be used in lieu of thermometer test well and pressure gauge tapplings.
- B. Use threadolets or tee fittings to mount gauge tapplings or test stations. Install fittings for side mounting to avoid collection of air or dirt.

3.7 PIPE EXPANSION DEVICES

- A. Stretching of expansion joints or connectors to correct for piping misalignment is not allowed.
- B. Install expansion loops, L-bends, Z-bends, and compensators where shown on drawings and as necessary to allow expansion and contraction in piping systems.
- C. Flexible Expansion Loops:
 - 1. Install loops in neutral or pre-extend condition as required for application. For steam service, install loops with flexible legs horizontal to prevent condensate buildup. Install and guide per manufacturer's recommendations.
- D. Flexible Ball Joints:
 - 1. Unless otherwise indicated, use minimum 2 ball joints at each station to accomplish required off set.
 - 2. Manufacturer's authorized representative shall be available for inspection of ball joints installation.
- E. Expansion Joints (Bellows Type):
 - 1. Stretching of expansion joint to correct for piping misalignment or to accommodate available end-to-end spacing shall not be allowed.
 - 2. Remove all shipping rods and spacers and clean inside of expansion joints thoroughly before putting joints into service.
 - 3. Install anchors and guides as specified herein and as shown on drawings prior to putting joints into service.
- F. Expansion Joints (Slip Type):
 - 1. Contractor shall be responsible for precompressing joints to allow for difference between installation temperature and minimum design temperature.
- G. Expansion Devices at Steam Heating Coils:
 - 1. Provide flexible connections at steam heating coils as specified in Section 23 0550 to accommodate expansion at piping connection to steam heating coils.

3.8 PIPELINE STRAINERS

- A. Provide drain valve at each strainer blowdown connection with hose threaded adapter and cap. Valve size shall be same as blowdown connection size.

- B. Install strainers in steam system on entering side of all automatic control valves and as indicated elsewhere. Install Y-type strainers in horizontal lines so that basket is in horizontal plane to prevent condensate build-up in basket.
- C. Install strainers in water systems on suction side of all pumps, entering side of automatic control valves of heating and cooling coils of air handling units, and as indicated elsewhere.
- D. Install clamped cover basket strainers in condenser water system as indicated.

3.9 STEAM TRAPS

- A. Install steam traps on discharge side of all steam using terminal apparatus, at steam headers, at steam mains, at end of steam mains, at end of branch piping exceeding 10 ft, at points where steam piping must rise, and elsewhere as indicated on drawings. Individually trap each coil of steam coil bank. Unless otherwise indicated, provide steam main drip/legs at intervals not exceeding 300 ft.
- B. Install to permit gravity flow of condensate to trap.
- C. Install valved test tee on discharge of each trap.
- D. Unless otherwise shown, do not lift condensate from discharge of any trap without written permission of Engineer.
- E. Support traps weighing over 25 lbs independently of connecting piping.
- F. Unless otherwise indicated, drip traps shall be inverted bucket.
- G. Unless otherwise indicated, equipment traps shall be float and thermostatic.

3.10 AIR SEPARATORS

- A. Provide valved blow down connections and extend drain piping to nearest floor drain.

3.11 PUMP SUCTION DIFFUSERS

- A. Pipe blow down to the nearest floor drain with drain valve at unit.
- B. Remove disposable fine mesh start-up strainers after start-up. Clean permanent strainer and replace after pipe cleaning process.

3.12 AIR VENTS

- A. Install manual air vents at all high points in water systems where air may collect and where shown on drawings.
- B. Install automatic air vent at top of air separator and where shown on drawings. Provide shut-off valve to isolate air vent from system. Pipe automatic air vent to the nearest floor drain.
- C. Install high capacity automatic air vent at air separator.

3.13 THERMOSTATIC AIR VENTS

- A. Install thermostatic air vents where shown. Install vents at the highest points of steam chambers. Locate vents higher than outlet connections to chambers.

3.14 VACUUM BREAKERS

- A. Install vacuum breakers at steam condensate outlet from steam heating coils, at steam-to-water heat exchangers, and as required for proper condensate drainage at any other steam using apparatus.

3.15 FLOW ELEMENTS/FLOWMETERS

- A. Flow elements/flowmeters located in common piping after multiple pump discharge lines shall be furnished with hot tap feature.
- B. If flow elements/flowmeters are furnished by Control Contractor, this Contractor shall install them in accordance with manufacturer's installation instructions. Wiring of flowmeters will be provided by Control Contractor.

3.16 STRAIGHTENING VANES

- A. Provide straightening vanes where flow sensor manufacturer's installation instructions require greater length of straight upstream piping than can be obtained in available space.

3.17 STEAM VENT EXHAUST HEADS

- A. Install steam exhaust heads at top of vertical vent pipe. Pipe drain connection of exhaust head to roof drain leader. Do not discharge drain pipe to any location that will cause contact of hot condensate with roofing materials.

END OF SECTION

SECTION 23 3314 DUCTWORK SPECIALTIES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 23 0595 - Air Systems Test Adjust Balance
- B. Section 23 0902 - Control Valves and Dampers (Control and Smoke Dampers)

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

- A. Shop Drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Capacities
 - 3. Temperature/pressure ratings
 - 4. Materials of construction
 - 5. Dimensions
 - 6. Manufacturer's installation instructions and/or detailed drawings
 - 7. All other appropriate data
- B. LEED Submittals:
 - 1. Product Data for IEQ Prerequisite 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2007, Section 5 – “Systems and Equipment”.

1.4 DESIGN CRITERIA

- A. Products and materials shall conform to NFPA Section 90A, possessing flame spread rating of not over 25 and smoke developed rating no higher than 50.
- B. Ductwork specialties exposed to air stream, such as dampers, turning vanes and access doors, shall be of same material as duct or unit at where the specialties are mounted, unless otherwise noted.
- C. Unless otherwise noted, ductwork specialties shall be designed and constructed for pressure class of ductwork in which they are installed.

PART 2 - PRODUCTS

2.1 MANUAL BALANCING DAMPERS

- A. Manufacturers: Ruskin, Greenheck, Vent Products, Pottorff or Air Balance, constructed in accordance with SMACNA HVAC Duct Construction Standards, except as modified below.
- B. Rectangular Dampers:

1. For low pressure ductwork, for damper blade height up to 12", use single blade type with minimum 22 ga galvanized steel blade with minimum 3/8" rod for blade width up to 18", and with minimum 18 ga galvanized steel blade with minimum 1/2" continuous rod for blade width from 19" to 48". For damper blade height more than 12", use multiple blade type with minimum 16 ga galvanized steel channel frames, opposed blade linkage operation, with blades minimum 16 ga and 6" to 8" maximum blade width, minimum 1/2" continuous rod and 1/2" x 1/2" galvanized steel angle blade stops. Bearings shall be nylon or molded synthetic. Construct dampers over 48" in width or height in multiple sections with mullions.
 2. For high pressure ductwork, dampers shall be constructed to withstand maximum pressure of 6" WG at closed position and maximum velocity of 2500 fpm at open position. Frame and blades shall be constructed of minimum 16 ga with minimum 1/2" diameter or square rod.
- C. Single Blade Round Dampers:
1. For low pressure ductwork, damper shall have blade 24 ga, but no less than two gauges more than duct gauge. Rod shall be minimum 3/8" diameter or square continuous. Bearings shall be nylon or molded synthetic.
 2. For high pressure ductwork, damper blade shall be minimum 16 ga. Rod shall be minimum 1/2" square continuous and tack welded to blade. Provide sealed end bearing similar to Ventlok #609 and acorn nut type dial regulator similar to Ventlok #635 or 641.
- D. Provide damper operators with locking devices and damper position indicators. Sheet metal screws are not allowed in construction or installation of dampers. Use rivets or tack welds.
- E. Dampers shall be properly stiffened and fabricated to prevent vibration, flutter or other noise.
- F. Extend damper shafts through duct insulation or use elevated regulators for externally insulated ducts to accommodate specified insulation thickness.
- G. Segmented Blade (Iris) Dampers:
1. Damper shall be segmented blade (iris) type with 22 ga 316 stainless steel frame and blades. Casing leakage shall not exceed 6 cfm.
 2. Iris blade segments shall be internally linked and driven by manual adjustment knob. Linkage parts shall be fully encapsulated and out of air stream. Manual adjustment knob shall be factory calibrated to the exact aperture position and aligned with the K factor set point to provide linear response flow control.
 3. Accuracy of flow measurement shall be $\pm 5\%$. Assembled units shall be furnished with specific charts designed for exact size and blade aperture configuration. Air pressure taps shall be integral to damper frame and positioned on either side of blade segments.
 4. Dampers shall be similar to Ruskin Model VFBD35.

2.2 TURNING VANES

- A. Construct turning vanes in accordance with SMACNA HVAC Duct Construction Standards.
- B. Square Throat Elbow Turning Vanes (Vane Runner Length up to 18" and Vane Length up to 36"):
1. Use single thickness vanes having 2" radius and 1-1/2" spacing, 24 ga minimum. Construct vanes in accordance with SMACNA HVAC Duct Construction Standards.
- C. Square Throat Elbow Turning Vanes (Vane Runner Length over 18" or Vane Length over 36"):
1. Use double thickness vanes having 4.5" radius and 3.25" spacing, 24 ga minimum.

D. Radius Elbow Splitter Vanes:

1. Splitter vanes for radius elbows shall be extended entire length of fitting and constructed in accordance with SMACNA HVAC Duct Construction Standards.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers: Ruskin or Greenheck
- B. Dampers shall be multi-blade, weighted type with counter-balanced blades and with 12 ga galvanized steel frame and extruded aluminum airfoil-shaped blades equal to Ruskin Type CBS 92. Blade edges shall have silicon rubber seals with ball bearings. Dampers shall be suitable for flange and gasket connection to ductwork or fan outlet.
- C. Dampers shall be rated to maximum velocity of 4000 fpm, maximum temperature of 250°F and maximum system pressure of 5" WG for damper width of 60" and 14" WG for damper width of 12".
- D. Maximum damper leakage shall be 13.5 cfm/sf based on pressure differential of 1" WG.

2.4 FIRE DAMPERS

- A. Manufacturers: Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff Louvers and Dampers, or Ruskin
- B. Fire damper assemblies shall be listed by UL 555 with 165°F fusible link and shall meet construction standards as set forth in NFPA 90A.
- C. Fire resistance rating of fire dampers shall be as shown on drawings.
- D. Dampers shall be dynamic type dampers rated to minimum 2000 fpm and 4" WG.
- E. Dampers shall be curtain type with blades out of air stream when in open position. Where curtain type dampers are not available because of size, use multiple blade type dampers.
- F. For round ducts, dampers equal to Ruskin Model FDR25 may be used.
- G. Damper fire rating shall be compatible with rating of building surface in which damper is used.
- H. Submit UL installation details to showing mounting method and duct connection method.
- I. Where ceiling fire dampers are used, they are to be equal to Ruskin CFD(R) 2 or 3, UL Classified for installation in fire rated floor or roof/ceiling assemblies.

2.5 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Ruskin, Air Balance, Prefco, Greenheck, Nailor, Cesco, Pottorff, Louvers and Dampers similar to Ruskin FSD-60
- B. Dampers shall meet requirements of NFPA 90A. Dampers shall be 1-1/2 or 3 h rated as shown on drawings, leakage rated at no higher than leakage Class I (4 cfm/ft² at 1" WG and 8 cfm/ft² at 4" WG) under UL 555/555S at temperature category 350°F, and compatible with system static pressures. Furnish dampers with factory-mounted, caulked sleeves and damper operators.
- C. Dampers shall use airfoil shaped damper blades. Dampers shall be rated for minimum 4" WG static pressure and 2000 fpm air velocity.

- D. For round ducts, dampers equal to Ruskin Model FSDR 25 may be used.
- E. Operators shall be 120 V electric powered with auxiliary switch built in for position indication, factory installed outside airstream, linked to dampers for fail closed operation, and be UL Listed and labeled for the application. Operators to be capable of closing damper at pressures encountered in system.
- F. Dampers shall be furnished with heat sensor set at 165°F.
- G. Smoke detector required at each damper will be provided by Electrical Contractor.
- H. Submit UL installation details showing mounting method and duct connection method.

2.6 SMOKE DAMPERS

- A. Manufacturers: Air Balance, Johnson Controls, Ruskin, Greenheck, Nailor, NCA Manufacturing, Cesco, Pottorff, Louvers and Dampers or Prefco, similar to Ruskin SD-60.
- B. Dampers shall be leakage rated at no higher than Leakage Class I (4 cfm/ft² at 1" WG and 8 cfm/ft² at 4" WG) under UL 555S at temperature category 250°F. Furnish dampers with factory-mounted, caulked sleeve and actuator assemblies. Damper shall have 16 ga or heavier frame with air foil-shaped blades, rated to minimum 4" WG in closed position and to 2000 fpm in open position.
- C. For round ducts, dampers equal to Ruskin Model SDRS 25 may be used.
- D. Actuator assemblies shall be installed outside airstream, linked to damper for fail (normally) closed operation. Actuator shall be capable of closing damper at pressures encountered in system.
- E. Size smoke dampers as close as possible to duct size, but in no case is damper size to be less than duct size.
- F. Actuators shall be 120 V electric powered with auxiliary switch built in for position indication.
- G. Furnish damper test switch similar to Ruskin Model DTS.
- H. Smoke detector required at each damper will be provided by Electrical Contractor.

2.7 ACCESS DOORS

- A. Access doors shall be rectangular, minimum 22 ga frame and minimum 24 ga door, fit air tight with neoprene gasket and shall be suitable for duct pressure class. When access doors are installed in insulated ductwork or equipment provide insulated doors with insulation equivalent to what is provided for adjacent ductwork or equipment. Access doors constructed with sheet metal screw fasteners are not acceptable.
- B. Low Pressure Ducts (Pressure Class 2" and Under):
 - 1. Doors shall be hinged type with sash lock for exposed application and non-hinged type with cam latches for concealed application.
 - 2. Access doors constructed in accordance with SMACNA HVAC Duct Construction Standard (Figure 7-2) or similar to Ruskin Model ADC or ADH will be acceptable.
 - 3. Sandwich style access doors made by Ductmate, Ward Industries, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.
- C. High Pressure Ducts (Pressure Class 3" and Over):

1. Use access doors factory fabricated and rated by manufacturer's published literature for installation in systems with pressures to positive or negative 10" WG.
 2. Sandwich access doors made by Ductmate, Ward Industries, Pottorf, Greenheck, or Flexmaster are acceptable, provided that they meet insulation requirements.
- D. Kitchen Grease Exhaust Ducts:
1. Access doors shall be grease and air tight, passing ASTM E 2336 test standard, shall have ICC ESR. Access doors shall be furnished by duct wrap manufacturer as part of duct wrap system.

2.8 DUCT FLEXIBLE CONNECTIONS

- A. Manufacturers: Unless specifically indicated, Ventfabrics, Inc. or Duro Dyne, equal to Duro Dyne model indicated. Material shall be glass fabric, fire retardant, waterproof, air tight and comply with NFPA 90A and 701 (formally UL 214).
- B. General Supply, Return and Exhaust Ductwork:
1. Material for indoor use to be 30 oz per square yard, double coated with neoprene, tensile strength of 500 lbs x 500 lbs, tear strength of 13 lbs x 13 lbs, suitable for -40°F to 200°F continuous operation similar to Duro Dyne Neoprene.
 2. Material for outdoor use shall be combination of inner layer of Duro Dyne Neoprene and outer layer of 24 oz per square yard, coated with Hypalon, UV resistant, suitable for -40°F to 250°F, similar to Duro Dyne Durolon.
- C. Special Exhaust Ductwork:
1. Material for indoor use shall be 17 oz per square yard, teflon or silicon coated, tensile strength of 200 lbs x 250 lbs, tear strength of 50 lbs x 40 lbs, suitable for -65°F to 500°F, similar to Duro Dyne Thermafab.
 2. Material for outdoor use shall be combination of inner layer of Duro Dyne Thermafab and outer layer of Durolon.

2.9 SOUND ATTENUATING DEVICES

- A. Manufacturers: Industrial Acoustics Company, Semco, United McGill, Aeroacoustic, Vibro-Acoustics, VAW Systems, Price, or Ruskin
- B. Units shall be tested in accordance with ASTM E-477-06a silencer test standard in aero-acoustic test facility which is NVLAP accredited for ASTM E-477-06a Standard. Each test shall have been conducted within last 12 month period. Submit copy of laboratory's NVLAP accreditation certificate on dynamic insertion loss, self-noise power levels, and aerodynamic performance.
- C. Outer casing of units shall be not less than 22 ga G90 galvanized steel in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork for 8" WG or pressure class indicated for duct system, if it is higher than 8" WG. Seams shall be lock formed or continuously welded and mastic filled.
- D. Acoustic Materials:
1. Media shall be non-fiberglass containing 100% natural cotton fibers treated with EPA registered, non-toxic borate solution, "flash dried" to actively inhibit growth of mold, mildew, bacteria and fungi. Media shall not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC's) that can off-gas, and/or cause health concerns. Media shall be

100% recyclable. Media shall comply with UL181 and NFPA 90A. Media shall not cause or accelerate corrosion of aluminum or steel.

- E. Covering Materials:
 - 1. Covering material shall be Mylar film.
 - 2. Provide spacers between covering material and perforated metal.
- F. Ends of attenuators shall be covered at factory with plastic, heavy-duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuators. Caps shall not be removed until attenuator is installed in duct system.
- G. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.
- H. Sound Attenuating Devices for Exhaust Air Terminal Units Serving Fume Hood and Snorkel Exhaust:
 - 1. Tubular type constructed entirely of Type 304 stainless steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be continuously welded. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8" WG, inside to outside of casing.
 - 2. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.
- I. Sound Attenuating Devices for General Exhaust Air Terminal Units of Laboratory or Vivarium Exhaust Systems:
 - 1. Tubular type constructed entirely of galvanized steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be continuously welded. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8" WG, inside to outside of casing.
 - 2. Unless otherwise indicated, sound attenuating devices shall meet acoustical performance requirements as scheduled in each octave band frequency under the flow conditions.
- J. Sound Attenuating Devices for Fume Hood Exhaust Fans:
 - 1. Provide units at exhaust fan intakes and discharges as scheduled. Unit length shall be as scheduled.
 - 2. Rectangular type constructed entirely of Type 304 stainless steel, in accordance with recommendations in the latest edition of ASHRAE Guide and Data Book for high pressure rectangular ductwork. Seams shall be continuously welded. Units shall contain no sound absorptive material. Attenuation shall be accomplished by controlled impedance membranes and broadly tuned resonators. Units shall not fail structurally when subjected to differential air pressure of 8" WG inside to outside of casing.

2.10 BIRD AND INSECT SCREENS

- A. Bird screens shall be 1/2" square mesh formed with 0.063" diameter aluminum wire. Insect screen to be 18 x 16 with 0.017" diameter aluminum mesh.
- B. Frame shall be removable type of minimum 12 ga, extruded aluminum.

2.11 AIR MIXING DEVICES

- A. Manufacturers: Blender Products, Inc
- B. Units shall be not less than 0.08" aluminum of all welded construction.
- C. Units shall be completely fixed devices capable of providing mixed air temperatures within 6°F of theoretical values.

2.12 AIR FLOW MEASURING UNITS

- A. Furnished by Control Contractor.

2.13 REMOTE OPERATED VOLUME CONTROL DAMPERS

- A. Young Regulator Co. or Metropolitan Air Technology similar to Young Regulator Model 830 dampers, furnished with Bowden 270 Series remote cable controls.

2.14 PRESSURE RELIEF DOORS

- A. Similar to Ruskin Model PRD 18, Kees Model BO, or Pottorff Model PPR-B0 for positive pressure and Ruskin Model NRD 18, Kees Model BI, or Pottorff Model NPR-BI for negative pressure applications.
- B. Doors and frames shall be 12 ga galvanized steel with seal around door perimeter. Use galvanized steel or stainless steel to match ductwork material. Doors shall be double-wall, insulated, when installed in insulated ductwork.
- C. Doors shall open automatically to relieve excess pressure above set point and to close when pressure is reduced to less than 3" WG. Setting shall be adjustable from 3" to 8" WG with 1" WG increments in between.

2.15 INSTRUMENT TEST HOLES

- A. Manufacturers: Ventlok 699 (up to 1" insulation thickness) or Ventlok 699-2 (over 1" insulation thickness).
- B. Use concave gaskets for round ductwork.

2.16 CONTROL DAMPERS

- A. Furnished by Control Contractor.

PART 3 - EXECUTION

3.1 MANUAL BALANCING DAMPERS

- A. Install manual balancing dampers in supply, return and exhaust branch ducts, as shown on drawings and as required to regulate airflow to meet air balance requirements.
- B. Install manual balancing damper in branch duct to each diffuser and grille. Install dampers as close as possible to take-offs.
- C. Install balancing dampers so as not to flutter or vibrate and as far as possible upstream from the air outlet.

- D. Do not install balancing dampers in supply ductwork upstream of air terminal devices.
- E. Balancing damper is not required where terminal air device serves a single diffuser or grille.
- F. Do not install manual balancing dampers in the following exhaust ductwork:
 - 1. Fume hood exhaust ductwork.
 - 2. Kitchen hood exhaust ductwork.

3.2 TURNING VANES AND SPLITTER VANES

- A. Install turning vanes and splitter vanes as shown on drawings and as specified in Section 23 3114 – Ductwork, for rectangular elbows. Install turning vanes and splitter vanes in accordance with SMACNA Standards and/or manufacturer's recommendations.
- B. Turning vanes are not required in transfer air ducts.

3.3 BACKDRAFT DAMPERS

- A. Install backdraft dampers where indicated on drawings.
- B. Where motorized dampers are shown in exhaust fan discharge duct, or in duct connecting to relief or exhaust louver, backdraft dampers are not required unless specifically indicated. Where motorized dampers are not shown, provide backdraft dampers in these locations.

3.4 FIRE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS

- A. Install dampers where shown on drawings in accordance with manufacturer's installation instructions and requirements of NFPA 90A. Install dampers complete with mounting collars, retaining angles, connections to adjoining ductwork and duct access doors. Install duct access door at each damper with door size large enough to permit replacement of fusible links and resetting of dampers.
- B. Test and demonstrate proper operation of each damper after system is installed and ready for operation.
 - 1. Manually test each damper for proper operation by removing fusible link or actuating EFL or PFL. Repair or replace any damper that does not close completely. Replace fusible link and certify in writing that each damper was installed according to manufacturer's installation instructions and that each damper can be expected to close completely when fusible link melts.
 - 2. Notify Owner and/or Owner's representative at least 48 h prior to testing to allow for witnessing.
- C. Contractor shall provide letter from manufacturer's representative indicating that dampers are installed per manufacturer's installation instructions.

3.5 ACCESS DOORS

- A. Install access doors where specified, indicated on drawings, and in locations where maintenance, service, cleaning or inspection is required, including automatic dampers, fire dampers, smoke dampers, smoke detectors, fan bearings, heating and cooling coils, reheat coils, humidifiers, filters, bird/insect screens, valves and control devices within duct or casing, at outside air intake duct and at inlet side of turning vanes in return ductwork.
- B. Locate access doors for greatest ease of access.

- C. Size and quantity of duct access doors shall be sufficient to perform intended service, but not less than the following:

<u>Rectangular Duct Size</u>	<u>Minimum Access Door Quantity and Size</u>
14" and smaller	(1) 8" x 8"
12" to 15" and smaller	(1) 12" x 10"
16" to 21"	(1) 18" x 14"
22" to 27"	(1) 18" x 18"
28" to 47"	(1) 24" x 24"
48" to 96"	(2) 24" x 24"

<u>Round Duct Size</u>	<u>Minimum Access Door Size</u>
10" and smaller	8" x 4"
15" and smaller	12" x 8"
29" and smaller	16" x 12"
30" and over	24" x 18"

- D. Increase duct size to accommodate access door size indicated above where required.
- E. Access doors for fire dampers to be minimum 12x12 or larger as indicated above.

3.6 FLASHINGS

- A. Install counterflashings where shown on drawings. Install in accordance with SMACNA recommendations.

3.7 DUCT FLEXIBLE CONNECTIONS

- A. Connect ductwork to fans or casings containing rotating equipment or mounted on vibration isolators with duct flexible connections. Installed width shall be suitable for specific application but shall not be less than 4". Install flexible connections in accordance with SMACNA Standards with double lock or "Grip Loc" connection.
- B. Duct flexible connections are not allowed for fan connection serving kitchen hood, or perchloric acid hood.

3.8 SOUND ATTENUATING DEVICES

- A. Install sound attenuating devices as indicated on drawings and/or as scheduled.
- B. For modular installation of sound attenuators, install galvanized steel holding frame, gaskets, seals, supports and fasteners in accordance with manufacturer's recommendations for multiple unit installation.

3.9 INTAKE AND RELIEF HOODS

- A. Install hoods as shown on the drawings and/or as scheduled.
- B. General Contractor will install curbs furnished with hoods unless otherwise indicated.

3.10 BIRD AND INSECT SCREENS

- A. Provide bird screens or insect screens as indicated on drawings at louvers and at intake/exhaust openings.
- B. Unless otherwise indicated, provide bird screens where filters are specified and insect screens where filters are not specified.

3.11 AIR MIXING DEVICES

- A. Install air mixing devices as indicated on the drawings and/or as scheduled. Install devices and associated duct connection in strict accordance with manufacturer's recommendations.

3.12 AIR FLOW MEASURING UNITS

- A. Install where indicated on the drawings and/or as scheduled and in accordance with manufacturer's recommendations.

3.13 REMOTE OPERATED VOLUME CONTROL DAMPERS

- A. Install remote operated volume control dampers and remote operators as indicated on drawings.
- B. Install connecting wire in the wall.

3.14 PRESSURE RELIEF DOORS

- A. Install doors vertically where shown on drawings and in accordance with manufacturer's recommendations.

3.15 CONTROL DAMPERS

- A. Install dampers in locations indicated on drawings, as detailed and according to manufacturer's instructions.
- B. Install blank-off plates or transitions as specified in Control Sections.
- C. Provide adequate operating clearance and access to operators.
- D. For dampers located outdoor, provide weather protection enclosure for parts of damper such as linkage and actuator located outside of duct. Enclosure shall be removable and made of galvanized steel sheet.

3.16 SMOKE DAMPERS AND DETECTORS

- A. Install smoke dampers in locations indicated on drawings. Allow room for operator installation and access to operator. Install access door in ductwork for access to damper. When damper is installed in location other than in smoke or fire rated wall, use SMACNA seal class A for ductwork between smoke damper and smoke rated wall for affected zone.
- B. Smoke detectors will be provided by Electrical Contractor in locations indicated on drawings. Install access door in ductwork for access to detector sampling device.

3.17 INSTRUMENT TEST HOLES

- A. Provide instrument test holes at air entering and air leaving side of all internal air handling system components for static pressure differential (ΔP) or temperature differential (ΔT) measurements.
- B. Provide ductwork instrument test holes as shown on drawings, or as directed by TAB personnel, or Engineer.

END OF SECTION

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SECTION 23-3400 FANS

PART 1 GENERAL

1.1 RELATED WORK

- A. Section 20-0513 - Motors
- B. Section 23-0550 - Vibration Isolation
- C. Section 26-2816 - Enclosed Switches and Circuit Breakers

1.2 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.
- B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

- A. Shop drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Fan curves
 - 5. Materials of construction
 - 6. Sound power levels
 - 7. Fan type, size, class, drive arrangement, discharge/rotation, bearings, drives
 - 8. Wheel type, diameter, rpm, tip speed
 - 9. Required fan horsepower including drive losses
 - 10. Motor data (refer to Section 20 0513 - Motors)
 - 11. Vibration isolators furnished with fans
 - 12. Dimensions and weights
 - 13. Special coatings where applicable
 - 14. Color selection charts where applicable
 - 15. Manufacturer's installation instructions
 - 16. All other appropriate data
- B. Fan curves shall include series of curves indicating relationship of flow rate (cfm) to static or total pressure for various fan speeds, brake horsepower curves, and selection range (surge curves, maximum rpm, etc).
- C. Indicate performance data, based on both design air quantity and 110% of design air quantity.

- D. For variable air volume application, indicate operating points at 100, 80, 60 and 40% of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and horsepower.

1.4 DESIGN CRITERIA

- A. Fan ratings shall be tested and certified in accordance with AMCA Standards 211 and 311 and fans shall bear AMCA Seal.
- B. Fans shall be furnished complete with motors, wheels, drive assemblies, bearings and accessories as hereinafter specified.
- C. Each fan wheel shall be statically and dynamically balanced to grade G6.3 per ANSI S2.19. Complete fan assembly shall be factory balanced statically and dynamically in accordance with Standard AMCA 204-96 for Balance Quality and Vibration Levels for Fans and meet or exceed guidelines in Application Category BV-3.
- D. For fans furnished with 5 HP or larger HP motors, each fan assembly shall have factory run test including vibration signatures taken on each bearing in horizontal, vertical and axial direction. Filter-in reading as measured at fan, scheduled rpm shall not exceed the following values when fan is rigidly mounted.
 - 1. Direct Drive 0.08 in/sec peak velocity
 - 2. Written records of run test and vibration test shall be available upon request.
- E. When fixed-pitch sheaves are furnished, system air balancing shall be accomplished by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves. This Contractor shall provide necessary trial and final sheaves and drive belts as required by TAB Contractor.
- F. Select each fan to operate at single stable operating point as predicted by fan curve. Fans having 2 potential operating points on fan curves are not acceptable.
- G. Sound power levels shall be based on tests performed in accordance with AMCA Standards 300 and 301.
- H. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. Motor furnished with fan shall not operate into motor service factor in any of these cases.
- I. Consider drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA Publication 203, Appendix L.
- J. Unless otherwise scheduled, AMCA Type A spark resistant construction shall be used for fans handling flammable or grease laden, vapors.

PART 2 PRODUCTS

2.1 PLENUM FANS

- A. Manufacturers: Greenheck, Barry, Chicago Blower, Twin City, or Cook.
- B. General: Fans shall be airfoil centrifugal type designed for industrial duty and suitable for continuous operation. Fans shall be single width, single inlet, arrangement 3, plenum fans with capacities and operating characteristics as indicated on schedules.

- C. Hubs: Hubs shall be cast or welded fabricated hubs with straight bores and keyways. Hubs shall be screwed to the shaft with a minimum of 2 set screws for positive attachment. Hubs using taper lock bushings are not acceptable.
- D. Wheels: Airfoil type, double skinned and welded to center and wheel sideplates. Fan impeller diameters shall conform to AMCA Standard 99-2401-82. Fan blades shall be designed to provide smooth airflow over all surfaces of blade. Fan shafts shall be solid AISI 1040 or 1045 steel. Straight shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shaft shall be sized to run at a minimum of 20% greater than the maximum AMCA class speed.
- E. Bearings: Air handling quality, heavy-duty, grease lubricated, pillow block, self-aligning ball or roller type. Bearings shall be selected for minimum life (ABMA L10) of not less than 80,000 hr operation at maximum cataloged operating speed.
- F. Screen Enclosure: Entire plug fan and drive assembly shall be encased with protective screen enclosure. Enclosure shall be constructed of aluminum or galvanized steel mesh or expanded metal and sized to have no measurable system effect on fan performance. Screen shall be reinforced as required to maintain stable structure during fan operation. Access shall be provided for periodic service. Door shall be of suitable size to allow service personnel into enclosure. Enclosure shall be designed and constructed to allow for complete disassembly.
- G. Inlet Screens: Heavy gauge, corrosion resistant, zinc plated steel wire for fans without inlet ductwork.
- H. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to insure full loading of blades. Inlet cones shall be heavy gauge steel.
- I. Painting: All metal parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install units as shown on drawings, and according to manufacturer's installation instructions. On units provided with drain connection, install drain valve and cap discharge of drain.
- B. Trade Contractor will install fans on existing room curbs per manufacturer's installation instructions and details.
- C. Perform field mechanical balancing, if necessary, to meet vibration tolerance specified in Section 23 0550 - Vibration Isolation.

3.2 COMMISSIONING

- A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

Fan Data Sheet

General

Project _____
Identification _____
Service _____
Location _____
Type _____
Manufacturer _____
Model Number _____

Performance

Capacity _____
Efficiency (%) _____
Brake Horsepower at design flow rate (cfm) _____
Brake Horsepower at 110% of design flow rate (cfm) _____

Physical Characteristics

Size _____
Class _____
Drive Arrangement _____
Discharge Rotation _____
Drive _____
Bearing _____

Motor

Manufacturer _____
Horsepower _____
Voltage _____
Phase _____
Hertz _____
RPM _____
Type _____
Enclosure Type _____
Frame Type _____
Insulation Class _____
NEMA Design Designation _____
Service Factor _____
Nominal Efficiency _____
Nominal Power Factor _____
Full Load Amps _____
Variable Frequency Drive Driven (Yes or No) _____

Miscellaneous

Vibration Isolators _____
Special Coating (Yes or No) _____
Special Coating Type _____

SECTION 23-4114 FILTERS

PART 1 GENERAL

1.1 RELATED WORK

- A. 23-7328 Factory Fabricated Custom Air Handling Units

1.2 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

- A. Shop drawings including, but not limited to, the following:
 1. Manufacturer's name and model number
 2. Identification as referenced in the documents
 3. Capacities/ratings; cfm, area, face velocity
 4. Efficiencies and initial/final pressure drop
 5. Materials of construction
 6. Dimensions
 7. Filter gauges data
 8. Manufacturer's installation instructions
 9. All other appropriate data

1.4 DESIGN CRITERIA

- A. Filters shall have UL, Class I or Class II listing.
- B. Holding frames or housings specified in this Section may be furnished by filter manufacturers listed below, or where applicable, as part of factory packaged air handling units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Camfil/Farr, Flanders Precisionaire, or Airguard unless otherwise noted under individual filter.

2.2 DISPOSABLE PANEL FILTERS (PRE-FILTERS)

- A. Cam-Farr 30/30 or approved equal by American Air Filter, Eco-Air or Airguard.
- B. Media shall be non-woven, cotton fabric material laminated to rigid backing to hold pleat formation, having minimum efficiency MERV 8 based on ASHRAE Test Standard 52.2 (average efficiency of 40% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Filters shall be UL Class 2 labeled.
- C. Filter housing shall consist of air handling unit manufacturer's low velocity filter section, or holding frame, as scheduled. When holding frame is indicated, it may be furnished by, filter manufacturer or it may be contractor fabricated.

- D. Media support shall consist of welded wire grid with 90% or more open face area. Grid shall be bonded to filter media.
- E. Filter enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board bonded to filter pack. Standard sizes shall be 12" x 24" x 2" and 24" x 24" x 2".
- F. Filters shall be capacity as scheduled. Clean filter pressure drop shall not exceed 0.28" WG based on 500 fpm face velocity.

2.3 DISPOSABLE RIGID CARTRIDGE TYPE AIR FILTERS (FINAL FILTERS)

- A. Similar to Farr E-Series RIGA-FLO or equal by American air Filter, Airguard or Eco-Air.
- B. High performance deep pleated, rigid, disposable type filters. Filters shall be constructed without use of steel components. Each filter shall consist of high efficiency media, enclosing frame, contour stabilizers on both air entering and exiting sides and support grilles. Filters shall be designed to withstand minimum differential pressure of 6" WG without structural damage to filter frame, seals or media. Filters shall be UL Class 2 labeled.
- C. Media shall be high density microfine glass fiber laminated to non-woven synthetic backing to form a lofted filter blanket.
- D. Media support shall be welded wire grid with effective open area of not less than 96%. Grid shall be bonded to filter media to eliminate media oscillation and pull away. Grid shall support media both vertically and horizontally. Contour stabilizers shall be permanently installed on both air entering and exiting sides of filter media pack to insure pleat configuration is maintained throughout life of filter.
- E. Enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled to provide rigid and durable enclosure for filter pack. Frame shall be bonded to filter pack. Standard sizes shall be 12" x 24" x 12" and 24" x 24" x 12".
- F. Filter thickness, size and capacity shall be as scheduled.
- G. Filters shall have minimum efficiency MERV 11 based on ASHRAE Test Standard 52.2 (average efficiency of 60-65% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Initial resistance at 500 fpm face velocity shall not exceed scheduled pressure drop.
- H. Filters shall have minimum efficiency MERV 14 based on ASHRAE Test Standard 52.2 (average efficiency of 90-95% based on ASHRAE Test Standard 52.1) with a minimum arrestance of 90%. Initial resistance at 500 fpm face velocity shall not exceed scheduled pressure drop.

2.4 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS (FUTURE)

- A. Filter size, capacity, and static pressure drop shall be as scheduled.
- B. Filters to be individually tested and certified shall be 99.97% minimum efficient with handling 0.3 micron particles in accordance with DOP test method. DOP efficiency along with filter serial number and name of manufacturer shall be marked on filter.
- C. Each filter element shall consist of glass fiber media, fire retardant epoxy or self-extinguishing neoprene rubber sealer and neoprene gasket all contained in suitable protected steel frame. Each filter element shall be constructed without use of spacers of any kind, including separators, tape, string or strips of medium by self-supporting pleating continuous sheet of formed, corrugated medium. Mount filters in side access housing or holding frames specified elsewhere in this section.

- D. Filters to be listed or classified under UL 586 test standard.

2.5 CARTRIDGE CHARCOAL FILTERS (FUTURE)

- A. Air filters shall be compact 12” deep adsorber type with combination sorbent/particulate removal media, impact-resistant plastic end caps, plastic vertical support channels, and a nominal 1” header for front or side-access applications.
- B. Filter cartridge sizes shall be 24”x24”x12” except as required to maximize filter surface area, 24”x12”x12” cartridges shall be acceptable.
- C. Filter media shall be specifically manufactured for the removal of molecular and particulate contaminants. Sorbent shall be broad spectrum grade of carbon incorporating Rapid Adsorption Dynamics (RAD) designed for the removal of a wide range of odors and VOCs.
- D. The media shall be formed into uniform pleats using hot-melt separators, assembled into multi media packs and bonded into a high-impact resistant plastic frame to prevent air bypass. Filter assemble shall include after filter as necessary to prevent carbon dust from traveling downstream.
- E. Resistance to airflow shall not exceed 0.48 inches w.g. at 500 feet per minute velocity.
- F. The media shall have a particulate removal efficiency of MERV of 13 when tested per ASHRAE Standard 52.2.

2.6 FILTER HOLDING FRAMES

- A. Frames shall be minimum 16 ga galvanized steel construction with provisions for assembly in a bank. Frames shall be suitable for filters scheduled and incorporate gaskets and spring clips to prevent air bypass.

2.7 LOW VELOCITY FILTER SECTIONS

- A. Provide for factory packaged, air handling units and cabinet fans as indicated.
- B. Housing shall consist of modular steel section with hinged access doors for filter replacement. Each housing shall be internally insulated by manufacturer or externally insulated in the field. Factory applied internal insulation shall have thermal resistance equivalent to that specified for duct in which housing is located, shall have internal vapor barrier, and shall have flame spread and smoke developed ratings as specified in Section 20 0700 - Mechanical Systems Insulation.

2.8 FILTER PRESSURE DROP GAUGES

- A. Dwyer Series 2000 Magnehelic pressure gauge.
- B. Unless otherwise indicated below, select scale range to be most appropriate to clean and dirty filter pressure drops.

<u>Filter Type</u>	<u>Scale Range (inch WG)</u>
Pre-Filters	0 - 1.0
Final Filters	0 - 2.0
HEPA filters	0 - 4.0
Charcoal filters	0 - 2.0

- C. Provide gauges for each filter bank, including gauges across each individual filter bank in built-up rack assemblies, suitable for flush mounting in a panel, including air filter gauge accessory package for use with 1/4" OD copper tubing.
- D. Provide 3/4" spacer at one 2' x 2' filter section between filter elements in built-up rack, adjacent to unit wall for placement of intermediate pressure probe.

2.9 REPLACEMENT FILTERS

- A. Enough media for 3 filter changes shall be provided for each air handler (excluding HEPA and carbon filters), 2 construction sets and 1 final set. Media used during construction shall be replaced when system is air balanced. Filters shall be like new at the time of turn over to the owner.

2.10 FILTER CLIPS

- A. Provide 2" long "D" style holding clips for pre-filters.
- B. Provide 3/4" long "D" style holding clips for final filters.
- C. Provide swing bolt style holding clips with hand turn knobs for HEPA filters.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install filters as shown on drawings and according to manufacturer's instructions.
- B. Provide supports as required and necessary clearance for changing filters.
- C. Provide structural supports, outside casing and blank-off materials for all field assembled filter banks, and filter banks where housings are not furnished by filter manufacturer.

3.2 FILTER PRESSURE DROP GAUGES

- A. Mount gauge near each filter bank and install static pressure sensors according to manufacturer's instructions.
- B. Mount gauge on control panel.

END OF SECTION

SECTION 23-7328 FACTORY FABRICATED CUSTOM AIR HANDLING UNITS

PART 1 GENERAL

1.1 RELATED WORK

- A. Section 20-0513 - Motors
- B. Section 20-0529 - Mechanical Supporting Devices
- C. Section 23-0550 - Vibration Isolation
- D. Section 23-0902 - Control Dampers
- E. Section 23-2116 - Pipe and Pipe Fittings
- F. Section 23-2118 - Valves
- G. Section 23-2120 - Piping Specialties
- H. Section 23-3314 - Ductwork Specialties
- I. Section 23-3400 - Fans
- J. Section 23-4114 - Filters
- K. Section 23-8216 - Coils
- L. Section 23-8413 - Humidification Equipment
- M. Section 26-0519 - Low-Voltage Electrical Power Conductors and Cables
- N. Section 26-0533 - Raceway and Boxes for Electrical Systems
- O. Section 26-2726 - Wiring Devices
- P. Section 26-2816 - Enclosed Switches and Circuit Breakers
- Q. Section 26-2913 - Enclosed Controllers

1.2 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplemental Conditions, and sections under Division 01 General Requirements.
- B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 SUBMITTALS

- A. Shop drawings for all equipment including, but not limited to, the following:
 - 1. Appropriate identification
 - 2. Complete drawings showing plans and sections including details of construction
 - 3. Overall unit dimensions and individual components and sections dimensions
 - 4. Shipping and operating weight of unit and/or sections
 - 5. Structural design load
 - 6. Details of component support
 - 7. Capacities/ratings
 - 8. Materials of construction
 - 9. Thermal and acoustical performance of wall, roof and floor panels
 - 10. Pressure ratings and leakage ratings
 - 11. Thermal break construction details and performance calculations or test data
 - 12. Each component manufacturer's name, model number and data. (Refer to each component section for submittal requirements.)
 - 13. Air leakage rates and test data
 - 14. Wiring diagrams and terminal points for control panels provided with units
 - 15. Manufacturer's installation instructions
 - 16. Air handling unit manufacturer's local representative and phone number

1.4 DESIGN CRITERIA

- A. For housings and floors operating under positive pressure (fan discharge side), maximum allowable deflection shall not exceed 1/200th of any span in any direction at + 10" WG.
- B. For housings and floors operating under negative pressure (fan inlet side), maximum allowable deflections shall not exceed 1/200th of any span in any direction at - 10" WG.
- C. Air handling unit manufacturer shall provide equipment as specified and install equipment furnished by others to result in complete and operational unit. Unit manufacturer shall assume single source responsibility for all air handling unit components and accessories.
- D. Furnish units complete with fans, piping, valves, piping specialties, actuators, motors, coils, humidifiers, drain pans, filter sections, damper sections and interior lighting, meeting configuration and as shown on drawings, specified and as scheduled. All unit components shall meet this Section of specification and all requirements specified in each section and division listed under Related Work. Control dampers shall be provided by unit manufacturer. Control dampers actuators will be furnished by Control Contractor for factory mounting by unit manufacturer.
- E. Unit performance shall be in accordance with ARI, Standard 430.
- F. All materials shall meet NFPA 90A flame and smoke generation requirements.

- G. All materials shall comply with FM Global insurance requirements.
- H. Unless otherwise indicated, galvanized steel shall be G90 according to ASTM A924 (formerly ASTM A525), A653 and ASTM A-90 and aluminum sheet shall be 3003-H14 alloy, conforming ASTM B209.
- I. Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure.
- J. Motor furnished with fan shall not operate into motor service factor in any cases.
- K. Where inlet and outlet ductwork at any fan is changed from that shown on drawings, submit scaled layout of the change and system effect factor calculations, indicating increased static pressure requirement as described in AMCA Publication 201. This Contractor shall be responsible for any motor drive and/or wiring changes required as result of duct configuration changes at fan.
- L. Air handling unit static pressure to take into consideration actual static pressure loss of components furnished within unit and any system effects due to unit arrangement and inlet and discharge connections.
- M. Wire brush all welds with solvent and wipe clean all bare metal before painting.
- N. Unit dimensions shall reflect space provided on plans including access allowances for equipment maintenance and overhead clearance requirements for stacked units located on raised structural platforms. All access aisle clearances shall be maintained as indicated on drawings to allow future AHU installation and replacement. Shipping splits shall allow installation of units within constraints of available access space.

1.5 FINAL CLEANING

- A. Outside and inside of each air handling unit shall be thoroughly cleaned. Use industrial grade cleaners to remove construction dust, sheet metal mil finish or grease. All proposed cleaning materials shall have contents identified and approved prior to use. Cover unit openings with sheet metal or other proper material until ductwork is connected to maintain unit cleanliness.

1.6 MANUFACTURER QUALIFICATIONS

- A. Air handling units shall be manufactured by qualified unit manufacturer that has been making custom units for at least 10 years, and shall carry manufacturer's nameplate. Unit manufacturer shall be held responsible for specified performance of units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Governair/Ventrol, Ingenia, TMI Climate Solutions, Air Flow Equipment, ClimateCraft or Trane Custom with operating characteristics as scheduled and physical dimensions as shown on drawings and/or detailed.

2.2 UNIT BASE

- A. Unit base shall be fabricated from structural steel or galvanized formed steel.

- B. Base shall be sized to provide sufficient height above floor to accommodate cooling coil drain trap height indicated on details. Additional steel base may be used as sub-base to provide the required trap height. Sub-base shall be provided by unit manufacturer.
- C. Weld steel solid at connection points to assure rigidity. Size perimeter steel to allow for rigging and handling.
- D. Locate and size base cross supports to support internal components.
- E. Provide lifting lugs to perimeter base steel. Incorporate means of attaching cable or chain into each lug.
- F. Base shall be split in maximum size pieces to allow for economical shipment to jobsite and placement within building. Provide bolting structural steel on both sides of split for field joining.
- G. Unit base shall be primed and finished with rust inhibiting epoxy paint. Galvanized dipped or powder coating may be used in lieu of epoxy paint. If base rail is not galvanized dipped, then the bottom of the base rails need to be painted to avoid rust issues.

2.3 UNIT FLOOR

- A. Unit floor shall be constructed to meet the maximum allowable deflection, and constructed of no lighter than:
 - 1. 3/16" aluminum plate or 1/8" aluminum plate with an increase in floor supports for framing. Floor plate shall have diamond-tread.
- B. Floor joints and seams shall be continuously welded water tight. Each section shall have turned up lip around section perimeter with welded corner to form drain pan type floor capable of retaining minimum 1-1/2" of water without leakage. Locate drain connection at lowest point of each pan type floor section. Connections shall extend through perimeter base channel and be welded water tight. Provide removable cap on each drain connection.
- C. Weld flooring material to structural members below. Drive screw attachment is not acceptable.
- D. Unit manufacturer shall field weld the unit floors as required to connect air handling unit shipping splits.
- E. Entire floor including base drain pans shall be insulated on underside to have same thermal and acoustical performance specified for unit housing. Insulation shall be supported by minimum 20 ga galvanized steel liner with joints sealed to provide continuous vapor barrier.
- F. Base Drain Pans:
 - 1. Provide recessed drain pans as integral part of unit floor in pre-heating coils, outside air sections and humidifier sections.
 - 2. Drain pans shall be constructed from minimum 16 ga 304 SS sheet, all seams continuously welded.
 - 3. Drain pan shall be double sloped; pitched down in direction of air flow and pitched sideways to drain connection.
 - 4. Locate drain connections at lowest point of pan, one on either end. Connections shall extend through perimeter base channel and be continuously welded to insure air-tight seal as well as eliminate requirement for backup wrench during field piping. Provide removable cap on each drain connection.

5. Refer to Cooling Coil Section for cooling coil drain pan requirements.

2.4 UNIT HOUSING

- A. Unit housing shall be constructed of minimum 3" thick double wall panels meeting thermal, acoustical and structural requirements specified.
- B. Panels shall utilize modular panel type construction. Panels may be self-supporting with internal support structure or supported by structural frame work.
- C. Panel joints and seams shall be sealed with proper gasket and caulking to meet maximum allowable housing leakage rate specified.
- D. Panel system, including service corridor where used, shall incorporate thermal break design at panel frames, joining mullions, supporting base, or corners. Thermal break is defined as prevention of condensation on outside surface of unit casing with 91°F dry bulb and 77°F wet bulb temperature in adjacent space and 50°F dry bulb temperature inside air handling unit.
- E. Unit manufacturer shall submit, as part of shop drawings, details of thermal break construction and calculations or test data indicating that thermal break design will prevent condensation on outside surface of unit casing with specified air temperatures at outside of unit and specified air temperature at inside of unit.
- F. Outer face of panels shall be constructed of no lighter than:
 1. 16 ga galvanized steel.
- G. Solid inner face of panels shall be constructed of no lighter than
 1. 22 ga 304 SS sheet
 2. All interior panel joints shall be sealed water and air-tight and suitable for low pressure washdown with a hose without wetting of the insulation.
 3. Unit casing shall be insulated with minimum 3 pcf density glass fiber, 2.5 pcf density polyisocyanurate, or 3 pcf density urethane foam insulation. Composite panel shall have heat transfer factor not greater than 0.06 Btu/hr/sq ft/°F. All products as applied shall meet NFPA 90A possessing flame spread rating of not over 25, fuel contributed rating of not over 50 and smoke developed rating of not over 50.
- H. Use solid inner surface for all sections.
- I. Provide center vertical partition to divide units into modules, as detailed on drawings. Partition panels shall be same construction as housing wall panels except both faces be constructed of no lighter than 16 ga solid galvanized steel.
- J. Provide blank-off panels with proper gaskets and sealants to prevent air bypass around equipment such as filters, coils, humidifiers and sound attenuators. Blank-off panels shall be constructed of galvanized steel no lighter than 16 ga unless otherwise noted. Blank-off panels at cooling coil sections shall be insulated with 3/4" thick insulation similar to AP Armaflex SA Duct Liner. Do not insulate blank-off panels between cooling coils located above drain pans.
- K. Panel manufacturer shall have published literature available stating sound absorption coefficient of panel system obtained using ASTM method of Test for Sound Absorption of Acoustical materials in
- L. Reverberation Rooms (ASTM Designation C423-66), and sound transmission loss obtained using procedures conforming to ASTM Designation E90-70, E413-70T and other pertinent standards.

1. Sound Transmission Loss in accordance with ASTM E90 shall equal or exceed the following:

Transmission Loss (dB) of 4" Panels	Octave Band Center Frequency (Hz)					
	125	250	500	1000	2000	4000
	21	24	34	44	51	53

2. Sound performance tests must be documented by independent laboratory (ETL, Riverbank Laboratories, Kideras Labs, etc.).
- M. Manufacturer shall have published literature available describing load-carrying capabilities and thermal characteristics of the panel system.

2.5 ACCESS DOORS

- A. Each unit section shall have 24" x 72" access door, unless shown differently on drawings.
- B. Fan section access door shall be sized to allow removal of fan wheel and motor through door, but not smaller than 30" x 72". If access door needs to be wider than 36", removable access panel may be provided.
- C. Access doors and door frames shall have similar thermal break construction as specified under Unit Housing.
- D. Access doors shall be same construction as housing panels.
- E. Access doors located downstream of cooling coils shall be true thermal break design with no metal to metal contact.
- F. Access doors shall be guaranteed tight closing through use of seals around entire periphery. Provide neoprene gasket between door frame and housing for air tight seal.
- G. Each access door shall contain 1/4" thick wire glass or double glazed tempered glass window minimum size of 12" x 12" or 12" round. Window shall be double paned with vapor seal construction.
- H. Each access door shall be furnished with corrosion resistant metal hinges or continuous piano hinge and shall have at least 2 stainless steel or aluminum alloy handles operable from either side.
- I. Doors shall open against higher air pressure to affect seal.

2.6 ACCESS SECTIONS

- A. Access sections shall allow minimum of 30" between adjoining equipment. Provide access doors as indicated on the plans.

2.7 REMOVABLE ACCESS PANELS

- A. Removable access panels shall be provided as indicated on drawings and where equipment removal is not possible through access door. Removable panels shall be same construction as housing panels.

2.8 AIR MIXING SECTION

- A. Provide air mixing devices as scheduled and per Section 23-3314 - Ductwork Specialties, with proper bulk needs and distances to dampers and coils per manufacturer's recommendations.

2.9 FILTER SECTIONS

- A. Filters shall be provided as specified and scheduled. Holding frames shall be installed by unit manufacturer to raise filters off floor and to prevent leakage as specified by unit manufacturer.
- B. Provide space in prefilter section, downstream of prefilters, for installation of future carbon filters.
- C. Each filter section shall have individual pressure gauges.

2.10 PREHEAT COIL SECTION

- A. Provide preheat coils, piping and internal piping as specified and indicated on drawings.
- B. Install coils, piping, and specialties not to block face area of coils. Terminate piping outside of unit casing for connection by Trade Contractor. Provide necessary pipe supports and hangers.
- C. Coil pull access is not available on both sides of units, therefore coil flanges, mounting, and blank-off provisions shall be arranged for upstream or downstream face pull. Refer to drawings and coordinate with internal component arrangement. Coil sizes and quantities at each unit shall allow for coil pull through access space shown on plans.
- D. Each coil shall be supported by galvanized steel frame which is independent of unit casing. Support frame shall allow individual coil removal. Blank-off panels shall be galvanized steel sheets with insulation as specified.

2.11 COOLING COIL SECTIONS

- A. Provide cooling coils, piping and piping specialties specified, and indicated on drawings.
- B. Install coils, internal piping, and specialties not to minimize blockage of face area of coils. Terminate piping outside of unit casing for connection by Trade Contractor. Provide pre-insulated pipe supports. Refer to spec 20 0529 for requirements.
- C. Each coil shall be supported by 304 stainless steel frame which is independent of unit casing. Support frame shall allow individual coil removal without disturbing any other coil or piping to any other coil. Coils shall be removable through unit access doors or removable access panels. Blank-off panels shall be 304 stainless steel sheet with insulation as specified.
- D. Coil pull access is not available on both sides of units, therefore coil flanges, mounting, and blank-off provisions shall be arranged for upstream or downstream face pull. Refer to drawings and coordinate with internal component arrangement. Coil sizes and quantities at each unit shall allow for coil pull through access space shown on plans.
- E. Each coil support shall include minimum 16 ga 304 stainless steel all welded condensate drain pan extending min. 4", but no more than 12" downstream of coil face. Each drain pan shall have sufficient depth to hold condensate water but not less than 2". Drain pan shall be sloped in 2 directions (pitched down in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4" per foot slope. Drain pan shall be individually piped down to drain pan located below, and bottom drain pan to be piped to hub drain at exterior of unit. Drain connection opening shall be flush with bottom of pan. Side pan connection located at lowest point of pan may be used only where bottom pan connection cannot be used. Drain pipe shall be 304 stainless steel with sufficient size, but not less than 1-1/2".
- F. Instead of drain pan under bottom coil, recessed pan, integral with unit floor shall be used. It shall be constructed as specified above including thermal insulation and drain lines, and shall incorporate required drain trap height.

2.12 FAN SECTION

- A. Fan and motor shall be provided as scheduled and meet requirements of appropriate Specification Sections.
- B. Fan and motor shall be factory mounted on vibration isolation equipment meeting requirements of Section 23 0550 - Vibration Isolation. Vibration base shall include integral adjustable motor base. If inertia bases are required, provide required concrete in factory.
- C. Motor Removal:
 - 1. For motors 5 hp and larger, provide motor removal rail sized for L/400 deflection when fully extended and subjected to weight of motor at furthest extreme position.
 - 2. Removal rail shall be mounted in fan section, centered with the fan section access door, perpendicular to side of AHU.
 - 3. Removal rail shall be designed with roller so motor can be fully removed from unit to distance equal to the motor diameter plus minimum of 6", and lowered onto dolly with traversing arm able to freely move while carrying motor weight.
 - 4. Motor shall be able to be removed through access door or access panel.
- D. Fan Array:
 - 1. Fan array system shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for duty specified. Fans shall be selected to deliver scheduled airflow quantity at scheduled operating total static pressure and scheduled fan/motor speed. Fan array shall be selected to operate at system total static pressure that does not exceed 90% of scheduled fan's peak static pressure producing capability at scheduled fan/motor speed. Each fan/motor cube shall include 11 ga, A60 Galvanized steel intake wall, 14 ga spun steel fan inlet funnel, and 11 ga G90 Galvanized steel motor support plate and structure. Fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. Motors shall be standard pedestal mounted type, T-frame motors selected at specified operating voltage, rpm, and efficiency as needed to meet performance requirements. Motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance. Maximum allowable Fan motor size shall be 15HP.
 - 2. Fan array shall provide uniform air flow and velocity profile across entire air way tunnel cross section. Airflow and velocity shall not exceed scheduled cooling coil and/or filter bank face velocity when measured at a point 12" from intake side of fan wall array intake plenum wall, and distance of 48" from discharge side of fan wall intake plenum wall.
 - 3. Provide partition between fans to minimize system effect.
 - 4. Provide structural frame to support upper fans with solid floor panel partition between fans as shown on drawings to minimize system effect.
 - 5. Each fan/motor cube shall be equipped with metal grating fan outlet guard.
 - 6. Each fan in array shall be provided with back flow prevention means that produces less than 0.10" of static pressure drop and/or system effect when that fan is enabled. Any such system effects and/or pressure drops shall be submitted and included as component in determining fan system total static pressure as submitted. Manufacturer's pressure drop ratings of any such equipment, developed from straight run test conditions will not be accepted.
 - 7. Fan array shall be sized such that upon single fan failure, remaining fans could ramp up and provide same 100% design capacity.
 - 8. Provide local electrical disconnect and overload protection for each fan.
 - 9. Contractor shall provide all wiring to air handling unit components that require power.

2.13 HUMIDIFIER SECTION

- A. Provide humidifiers, piping and supports as specified, and indicated on drawings. Terminate piping outside of unit casing for connection by Trade Contractor.
- B. Size and locate humidifier distribution tubes to receive uniform air flow on entire tube.
- C. Provide required absorption distance between humidifier and downstream equipment or housing wall.

2.14 BIPOLAR IONIZATION

- A. Provide bipolar ionization, similar to Global Plasma Solutions needle point ionization system, upstream of cooling coils.
- B. Provide ion detector, similar to Global Plasma Solutions iDetect, to provide BAS status of the ionization system.

2.15 DISCHARGE AIR SECTION

- A. Provide with framed discharge opening or spun bellmouth fitting conforming to size and configuration of the ductwork.

2.16 CONTROL DAMPERS

- A. Refer to Section 23 0902 - Control Valves and Dampers for control dampers.

2.17 FLOOR OPENING PROTECTION

- A. Floor openings shall have safety grates using 1" x 1/8" steel bar stock on 1-1/4" center spacing. Grates shall have same finish as floor. Provide 1-1/2" lip of galvanized steel at entire perimeter of opening.

2.18 CONTROLS

- A. Control devices shall be by same manufacturer providing control devices for the remainder of the building.
- B. Control devices will be furnished by Control Contractor and shall be field installed by Trade Contractor and as described in control section of specifications.

2.19 TESTING

- A. Owner and/or Owner's representative may elect to witness tests. Notify Owner and/or Owner's representative of test date at least 2 weeks in advance. Submit certified test data to Engineer for approval.
- B. Unit manufacturer shall provide factory tests to verify casing leakage after units are assembled.
- C. Unit manufacturer and installing contractor shall jointly provide field tests to verify casing leakage after units are installed at jobsite. Coordinate with Electrical Contractor for power to unit test fan.
- D. Casing leakage tests shall verify that unit casing leakage is less than 0.5% of design air flow at one and a half times design total static pressure (TSP).
 - 1. Seal duct openings in positive pressure section. Connect this section to fan developing 1-1/2 times the design positive static pressure and read air flow of this fan using approved air flow

- measuring device. Fan air flow measurement shall be considered casing leakage of this Section.
2. Seal duct openings in suction side of unit. Connect this section to fan developing in 1-1/2 times the design negative static pressure and read fan air flow of this fan using approved air flow measuring device. Fan air flow shall be considered casing leakage of this Section.
 3. Conduct casing leakage test individually for each air handling unit. Total casing leakage shall be calculated as sum of positive pressure section leakage and negative pressure sections leakage. Total casing leakage shall not exceed the allowable rate specified above.
- E. Unit manufacturer shall provide factory panel deflection test. Conduct this test in conjunction with casing leakage testing.
1. Panel deflection test for panels under positive pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG positive, whichever is greater.
 2. Panel deflection test for panels under negative pressure shall verify that unit casing deflection is less than 1/200 of the longest plane being measured at 1-1/2 times design static pressure or 10" WG negative, whichever is more negative.
 3. Deflection shall be measured at 2 points for positive pressure sections and 2 points for negative pressure sections (total 4 points at panel seams) at mid-point of panel height

2.20 ELECTRICAL SERVICE

- A. Provide adequate lighting and switching so equipment can be observed and maintained in safe manner. Each unit section shall contain a minimum of one light fixture. Sections wider than 12 ft shall have multiple light fixtures with maximum spacing of 6 ft.
1. Provide light switch with pilot light for each access section. Locate switch near access door.
 2. Provide timer for light switch to automatically turn off lights after preset time. Timer shall be similar to Intermatic Model FF2H with 0-2 hour range and hold feature to override automatic shut-off function.
 3. Light fixtures shall be: LED type. Provide bulbs for each fixture.
- B. Lights, switches, convenience outlets, wiring and conduit shall meet requirements of appropriate specification sections of Division 26.
1. Provide minimum of two convenience outlets on each unit, spaced evenly over length of unit.
- C. Wiring and conduit inside of unit shall be provided by unit manufacturer. Conduit shall be EMT and meet requirements of NEC and appropriate specification sections of Division 26. Provide junction box for each motor at outside of unit wall and provide single point of connection for both 480V, 3-phase and 120V, single-phase power for connection by Electrical Contractor.
- D. PVC coated LFMC is not allowed in environmental air plenum spaces or air handling equipment
- E. Seal electrical penetrations through unit air-tight.

2.21 PIPED SERVICE

- A. Piping and equipment installation inside the unit shall be complete. Piping shall be installed and tested per appropriate specification section. Unit manufacturer shall be responsible for any leaks, which occur in unit during system testing which occurs before system startup.
- B. Extend piping for each coil and humidifier if used through panel casing. Terminate piping with flange for pipe 2-1/2" and larger or threaded connection for pipe 2" and smaller with caps.

PART 3 EXECUTION**3.1 INSTALLATION**

- A. Units shall be assembled in modules in unit manufacturer's plant to allow for testing of complete unit.
- B. Unit manufacturer shall supervise installation of units and all field joining of the modules, including and sheet metal, electrical and piping.
- C. Joints in floor between modules shall be fully welded to be air and water tight.
- D. Unit manufacturer shall provide and install all equipment within unit as specified and/or scheduled, including fans, motors, coils, humidifiers, dampers, sound attenuating devices, piping, piping specialties, ductwork specialties, lights, switches and all equipment necessary to complete air handling equipment contained within housings. Mechanical and electrical connections (i.e., piping and conduit) shall be stubbed through housing so that appropriate contractor may provide service to air handling unit. Electrical wiring and control wiring shall terminate in junction boxes on accessible side of unit.
- E. Provide structural steel sub-base as required. Refer to Unit Base in Part 2.
- F. Field mounting of any equipment on housing walls or roof is not allowed without prior approval of Engineer. No field mounting of any services that will restrict access to fan and coil sections is permitted.
- G. Unit manufacturer and installing contractor shall coordinate with other trade Contractors, all necessary requirements to assure proper air handling unit installation including module sizes necessary for installation of units within space available and final housekeeping pad dimensions.
- H. Piped services to units, including electrical conduits, shall not cover fan and coil access sections.

3.2 INSTRUMENT TEST HOLES

- A. Provide instrument test holes at air entering and air leaving side of all internal air handling unit components for static pressure differential or temperature measurements. Refer to Section 23-3314 - Ductwork Specialties for instrument test holes.

3.3 PROTECTION OF OPENINGS

- A. Protect openings on housings during construction against entry of foreign matter and construction dirt.

3.4 FIELD TESTING & COMMISSIONING

- A. Unit manufacturer and installing contractor shall jointly perform field casing leakage tests on each completed housing assembly as previously specified and shall be responsible for repair of all leaks. Submit certified test data to Engineer for approval.
- B. Unit manufacturer shall be present for air handling unit commissioning. Coordinate date and time of commissioning with construction manager.
- C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

- D. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 23-8216 COILS

PART 1 GENERAL

1.1 RELATED WORK

- A. Section 23 7328 – Factory Fabricated Custom Air Handling Units

1.2 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 SUBMITTALS

- A. Shop drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Flow rate and pressure drop
 - 5. Materials of construction
 - 6. Dimensions and weights
 - 7. Manufacturer's installation instructions
 - 8. All other appropriate data

1.4 DESIGN CRITERIA

- A. This Section covers coils in factory-packaged air handling unit, custom air handling units and field-erected air handling units.
- B. Coil sizes, capacities, configuration and operating characteristics to be as shown on plans and/or as scheduled. Coil performance data shall be certified in accordance with ARI Standard 410.
- C. Temperature profile of discharge air from entire coil face shall be uniform within 12" of coil face.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Buffalo, Carrier, McQuay, Trane, Marlo, Heatcraft, Aerofin, RAE, or Temtrol.

2.2 HOT WATER COILS

- A. Coils shall be constructed of 0.035" tube wall, 1/2" or 5/8" OD seamless copper tubes with 0.0095" aluminum fins suitable for working pressures to 200 psig and temperatures to 220°F. Coils shall be tested at 250 psig under water.
- B. Coil fins shall be continuous serpentine or plate fin type.
- C. Coil headers shall be cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.

- D. Casings shall be minimum 16-gauge galvanized steel having galvanized steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.
- E. Coils shall be equipped with bronze spring turbulators where required to provide capacities indicated.

2.3 CHILLED WATER COILS

- A. Coils shall be constructed of 0.035" tube wall, 1/2" or 5/8" OD seamless copper tubes with 0.0095" aluminum fins suitable for working pressures to 250 psig. Coils shall be tested at 250 psig under water.
- B. Coil fins shall be continuous plate fin type.
- C. Coil headers shall be constructed of cast iron with tubes expanded into headers, steel pipe with brazed tube connections, or heavy seamless copper with tubes brazed to header.
- D. Casings shall be minimum 16 ga stainless steel having stainless steel end supports and top and bottom channels of rigid construction with allowance for expansion and contraction of finned tube section.
- E. Select coils for tube velocity not less than 3.0 fps.
- F. Maximum allowable fin spacing shall be 10 fins per inch. Coil depth shall not exceed 8 rows.

PART 3 EXECUTION

3.1 GENERAL

- A. Install coils as indicated on drawings and/or as detailed. Pitch coils for proper drainage according to manufacturer's installation instructions. Install shims as required.
- B. Clean oil film from coil fins with hot water/detergent as recommended by coil manufacturer.
- C. Comb out fins when bent or crushed before enclosing coils in housing. Clean dust and debris from each coil to ensure its cleanliness.
- D. Provide flanges or joints in piping to facilitate coil removal. Unless otherwise specified, pipe coils for counter flow arrangement.
- E. Provide air vent and drain valve at each water coil.

END OF SECTION

SECTION 23-8413 HUMIDIFICATION EQUIPMENT

PART 1 GENERAL

1.1 REFERENCE

- A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 QUALITY ASSURANCE

- A. Manufacturer's Qualifications:
 - 1. Manufacturing company shall have five (5) years experience with application of the specified humidification/evaporative cooling system for HVAC Systems.
 - 2. Manufacturing company shall have field service support and local representation to provide continuing support of humidification/evaporative cooling system.
- B. Codes and Standards:
 - 1. UL and NEMA Compliance: Provide electrical components required as part of evaporative cooling system, which are listed and labeled by UL and comply with NEMA Standards.
 - 2. Provide electrical control panels assembled and labeled in UL qualified facility.
 - 3. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of evaporative cooling system.
 - 4. International Mechanical Code and State Mechanical Code Rules.

1.3 SUBMITTALS

- A. Shop drawings including, but not limited to, the following:
 - 1. Manufacturer's name and model number
 - 2. Identification as referenced in the documents
 - 3. Capacities/ratings
 - 4. Materials of construction
 - 5. CV of control valves
 - 6. Absorption distances
 - 7. Dimensions
 - 8. All other appropriate data
 - 9. Electrical data and wiring diagrams for electric type humidifiers
 - 10. Maintenance data
 - 11. All other appropriate data
 - 12. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating pipe routing, nozzle locations, solenoid valves, dimensions, weight loadings, required clearances, and methods of assembly of components.

1.4 WARRANTY

- A. Provide one (3) year manufacturers warranty for replacement of defective parts and one (1) year contractor's warranty for installation of replacement parts.

PART 2 PRODUCTS**2.1 STEAM HUMIDIFIERS**

- A. Manufacturers: Pure Humidifier Co., Armstrong, Dri-Steem, or Nortec
- B. Unit shall be of steam jacketed manifold type, providing clean, dry steam humidification without condensate drip or objectionable steam noise.
- C. Furnish unit complete with control valve, inlet strainer, inverted bucket trap or F & T trap according to manufacturer's recommendation.
- D. Humidifiers shall be designed for complete absorption of steam within 18" inches of distribution grid.
- E. Provide temperature switch to prevent humidifier from operating before start-up condensate is drained.
- F. Provide multiple dispersion tubes where indicated or required for uniform steam distribution.
- G. Steam Control Valve:
 - 1. Control valve shall be normally closed modulating type with equal percentage flow characteristic from closed to approximately 30% open and linear flow characteristic above 30% open. Valve trim shall be stainless steel and designed to resist erosion of seat and plug. Refer to Section 23-0902 for actuator requirements.
 - 2. Control valve full capacity shall not exceed scheduled humidifier capacity by more than 20%. Control valve rangeability (ratio of maximum controllable flow to minimum controllable flow) shall be tested in accordance with ISA 575.11 flow characteristic standards and shall be 10:1 minimum.
- H. Humidifier Dispersion
 - 1. Steam dispersion panel similar to DriSteem Ultra-Sorb:
 - a. Factory-assembled steam dispersion panel shall include the following components:
 - 1) Steam supply header/separator
 - 2) Condensate collection header
 - 3) Steam dispersion tubes spanning distance between two headers
 - b. Each dispersion tube shall be fitted with steam discharge tubelets inserted into tube wall. Each tubelet shall be made of thermal-resin material designed for high steam temperatures. Two rows of tubelets in each dispersion tube shall discharge steam in diametrically opposite directions, perpendicular to airflow.
 - c. Each tubelet shall extend through wall of and into center of dispersion tube and contain steam orifice sized for its required steam capacity.
 - d. Each packaged humidifier panel assembly of tubes and headers shall be contained within galvanized metal casing to allow convenient duct mounting, or to facilitate stacking of and/or end-to-end mounting of multiple humidifier panels in ducts or air handling unit casings.
 - e. Tubes and headers shall be 304 stainless steel and be Heli-arc welded.

PART 3 EXECUTION**3.1 STEAM HUMIDIFIERS**

- A. Mount units in air handling units as indicated on drawings. Provide additional support for distribution manifolds as recommended by manufacturer.

- B. Install steam and condensate branch lines with minimum of 3 elbows to allow for expansion and contraction. Use pipe size as indicated on drawings or as recommended by manufacturer, whichever is larger. Ream pipe and blow out at full steam pressure before connection to humidifier.

3.2 COMMISSIONING

- A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

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SECTION 26 0519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 26 0529 - Hangers and Supports for Electrical Systems
- B. Section 26 0553 - Electrical Systems Identification
- C. Section 26 0593 - Electrical Systems Firestopping
- D. Section 26 0812 - Power Distribution Acceptance Tests
- E. Section 26 0813 - Power Distribution Acceptance Test Tables

1.2 REFERENCE

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. Section includes conductors and cables rated 600 V and less, connectors, splices, and terminations rated 600 V and less, sleeves and sleeve seals for cables.
- B. Conductor and conduit sizes in these contract documents are based on copper wire, and only copper wire shall be used.

1.4 REFERENCE STANDARDS

- A. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
- B. ASTM B 1 – Standard Specification for Hand-Drawn Copper Wire.
- C. ASTM B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- D. NEMA WC 3 – Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81).
- E. NEMA WC 5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-61-402).
- F. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-668).
- G. NFPA 70 – National Electrical Code.
- H. UL 44 – Thermoset-Insulated Wires and Cables.
- I. UL 83 – Thermoplastic-Insulated Wires and Cables.
- J. UL 486A-486B – Wire Connectors.

- K. UL 486C – Splicing Wire Connectors.
- L. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
- M. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Manufacturer’s Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.
- C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations of components and circuits.
 - 2. Operation and Maintenance Data:
 - a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.
- B. Wire and cable boxes and reels shall bear the date of manufacture.
 - 1. Date of manufacture shall not precede contract date by more than one year.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.8 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Cerrowire
- B. General Cable Corporation
- C. Senator Wire & Cable Company
- D. Southwire Company
- E. Approved equal

2.2 DESCRIPTION

- A. NEMA WC 70; single copper conductor insulated wire; 600V rated insulation; 90°C maximum operating temperature for dry and wet or damp locations.
 - 1. Thermoplastic-insulated wires and cables: NEMA WC 5, UL 83; Type THHN, THWN, THHW.
 - 2. Thermoset-insulated wires and cables: NEMA WC 3, UL 44; Type XHHW-2.

2.3 REMOTE CONTROL AND SIGNAL CIRCUITS

- A. Class 1
 - 1. Copper conductor, single insulated wire.
 - 2. Insulation type THHN, THHW rated 90°C, 600 V insulation class.
 - 3. Type XHHW-2 for ambient temperature less than 32°F.
 - 4. UL 83 listed, ASTM B 1 for solid conductors; ASTM B 8 for stranded conductors.
- B. Classes 2 and 3
 - 1. Copper conductor, multiple twisted conductors covered with an overall non-metallic jacket unless otherwise noted.
 - 2. Insulation type XLE, rated 105°C, 300 V insulation class.
 - 3. UL listed for use in space in which circuits will be installed.

2.4 CONNECTORS, SPLICES, AND TERMINALS

- A. Manufacturers:
 - 1. AFC Cable Systems, Inc.
 - 2. Burndy Division of Hubbell Incorporated
 - 3. Hubbell Power Systems, Inc.
 - 4. Ideal Industries, Inc.
 - 5. O-Z/Gedney; EGS Electrical Group LLC.
 - 6. 3M; Electrical Products Division
 - 7. Thomas and Betts Division of ABB
 - 8. Tyco Electronics Corp.
 - 9. Approved equal
- B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

2.5 TERMINATIONS

- A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.6 PLASTIC CABLE TIES

- A. Nylon or approved; locking type; metallic ties not permitted.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

- A. Install conductors in a raceway system, unless otherwise specified or indicated.
- B. Install conductors only after:
 - 1. Building interior is enclosed and weather tight
 - 2. Mechanical work likely to damage conductors has been completed
 - 3. Raceway installation is complete and supported
- C. Pull conductors into raceway at same time.
- D. Neatly train and lace conductors inside boxes, equipment, and panelboards.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- H. Provide adequate support for conductors not in raceway. Do not support conductors from ceiling grid or from accessible ceiling support systems.
- I. Support cables and conductors in vertical raceways per requirements in Section 26 0529 - Hangers and Supports for Electrical Systems.
- J. Identify and color-code conductors and cables according to Section 26 0553 - Electrical Systems Identification.
- K. Wiring at Outlets: Install conductor at each outlet, with minimum 12" of slack.
- L. Limit conduit fill to a maximum of 9 current-carrying conductors.
- M. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under terminal screws.

3.2 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders and Branch Circuits: Solid or stranded #10 AWG and smaller; stranded for #8 AWG and larger.
- B. Minimum conductor sizes shall be as follows:
 - 1. #12 AWG – Branch circuits of any kind.

2. #14 AWG – Remote control and signal systems, fire alarm system.

C. Branch wiring length limitations:

1. 208Y/120 V circuits over 100' in length: Increase wire size one size for each 100' of length. Increase conduit size as required.
2. 480Y/277 V circuits over 150' in length: Increase wire size one size for each 150' of length. Increase conduit size as required.

3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders: Type THHW, THWN, XHHW-2, rated 75°C for wet locations, single conductors in raceway.
- B. Branch Circuits: Type THHN, XHHW-2, rated 90°C for dry and wet or damp locations, single conductors in raceway.
- C. Wiring in Fluorescent Fixture Channels: Type THHN, rated 90°C for dry and damp locations, single conductors.
- D. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh strain relief device at terminations to suit application.

3.4 REMOTE CONTROL AND SIGNAL CIRCUITS

- A. Sizing – #14 AWG minimum.
- B. Installation:
1. Install cables in cable tray and cable rings.
 2. Provide protection for exposed cables where subject to damage.
 3. Support cables above accessible ceilings; do not rest on ceiling tiles.
 4. Use suitable cable fittings and connectors.

3.5 CONNECTORS, SPLICES AND TERMINALS

- A. Connectors:
1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
 2. Use compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG conductors and larger. Install with hydraulic compression tool.
 3. Use pre-insulated “twist-on” connectors with integral spring for splices and taps of #10 AWG normal power conductors and smaller.
 4. Use compression-set, insulated type for splices of #10 AWG and smaller conductors serving life safety loads. “Twist-on” connectors are not allowed in life safety circuits.
 5. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.
- B. Splices:
1. Splice wires and cable only in accessible locations such as within junction boxes.

2. Make splices to carry full capacity of conductors with no perceptible temperature rise.
3. Splices are to be made with compression barrel connector where no taps exist or allowance for future taps is being made.
4. Where the splice includes provisions for taps, use Burndy insulated Unitap. Locate in pull or junction box sized for all conductors to be spliced and tapped.
5. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat-shrinkable insulating tubing, or resin-filled insulator.
6. Use electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half-lapped layers of plastic electrical tape, for joints, taps, and splices of #1 AWG conductors and larger.
7. Plastic snap-on or piercing type mechanical splice insulators are not allowed.
8. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Terminals:

1. All terminals are to be compression type.
2. Train wires to eliminate fanning of stands, crimp with proper tool and die.
3. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
4. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
5. Torque screw termination per manufacturer's recommended values.
6. Terminate motor connections using the following methods:
 - a. 300V and below: Use compression-set, insulated eye terminal for screw lug connections or barrel type cable to cable connections.
 - b. Above 300V: Use 3M 5300 series insulated motor lead splicing kit.

3.6 CABLE TIES

- A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

3.7 FIELD QUALITY CONTROL

- A. Test 600 volt conductors and cables per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- B. Interpret test results in writing and submit to Engineer.
- C. Replace conductors and cables that are found defective, at no expense to Owner.

END OF SECTION

SECTION 26 0533 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 0526 – Grounding and Bonding for Electrical Systems
- C. Section 26 0529 – Hangers and Supports for Electrical Systems
- D. Section 26 0553 – Electrical Systems Identification
- E. Section 26 0593 – Electrical Systems Firestopping
- F. Section 26 2726 – Wiring Devices
- G. Related sections in other Divisions of Work:
 - 1. Section 27-0528.33 - Raceway and Boxes for Communications Systems

1.2 REFERENCE

- A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. Section includes raceways, fittings, wireways, outlet boxes, pull and junction boxes, floor boxes, tap boxes and raceway seals.

1.4 REFERENCE STANDARDS

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. ANSI C80-1 – Rigid Steel Conduit-Zinc Coated (GRS)
- C. ANSI C80-3 – Electrical Metallic Tubing-Zinc Coated (EMT)
- D. ANSI C80-6 – Intermediate Metal Conduit-Zinc Coated (IMC)
- E. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- F. ETL PVC-001 – Intertek ETL SEMKO High Temperature H²O PVC Coating Adhesion Test Procedure for 200hrs.
- G. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
- H. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
- I. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
- J. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit

- K. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing
- L. NFPA 70 – National Electrical Code
- M. UL 1 – Flexible Metal Conduit
- N. UL 6 – Electrical Rigid Metallic Conduit-Steel
- O. UL 360 – Liquid-Tight Flexible Steel Conduit
- P. UL 514A – Metallic Outlet Boxes
- Q. UL 514B – Conduit, Tubing, and Cable Fittings
- R. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings
- S. UL 797 – Electrical Metallic Tubing-Steel
- T. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings
- U. UL 1242 – Electrical Intermediate Metal Conduit-Steel
- V. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit
- W. BICSI – Telecommunications Reference Manual (TDMM), Latest Edition
- X. University of Kentucky - Communications and Network Systems – Telecommunications Standards

1.5 SUBMITTALS

- A. Product Data:
 - 1. Raceways
 - 2. Fittings
 - 3. Wireways
 - 4. Outlet boxes
 - 5. Pull and junction boxes
 - 6. Floor boxes
 - 7. Tap boxes
 - 8. Raceway seals
- B. Manufacturer’s Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.
- C. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual routing of raceways 2” and larger.
 - b. Record actual location and mounting heights of wireways, floor boxes, tap boxes, outlet, pull and junction boxes.

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with NFPA 70.
 - 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Protect PVC conduit from sunlight.
- C. Comply with manufacturer's written instructions.

1.8 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT (RMC)

- A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6; heavy wall galvanized steel.
- B. Intermediate Metal Conduit (IMC): ANSI C80.6, UL 1242; thinner wall, galvanized steel.
- C. Fittings (couplings, conduit bodies, connectors and bushings): NEMA FB 1, UL 514B; aluminum alloy; threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings; conduit bodies cover: stamped steel, with stainless steel screws and neoprene gaskets.
- D. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products; O-Z/Gedney; Appleton; Hubbell; Robroy Industries – Perma-Cote.

2.2 ELECTRICAL METALLIC TUBING (EMT)

- A. ANSI C80.3, UL 797; galvanized steel tubing
- B. Fittings (couplings, conduit bodies, and connectors): NEMA FB I, UL 514B; steel, watertight gland compression type connectors with double locknuts and insulated throat; conduit bodies cover: stamped steel, with stainless steel screws and neoprene gaskets. Indentor, drive-on, die-cast or pressure cast fittings not permitted.
- C. Fittings Manufacturers: Same as manufacturers listed in 2.1.D.

2.3 FLEXIBLE METAL CONDUIT (FMC)

- A. UL 1; interlocked steel
- B. Fittings: NEMA FB I, UL 514B; steel

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. UL 360; interlocked steel, with PVC jacket
- B. Fittings: NEMA FB 1, UL 514B; steel

2.5 RIGID NONMETALLIC CONDUIT (RNC)

- A. NEMA TC 2, UL 651; Schedule 40 PVC
- B. Fittings: NEMA TC 3, UL 651
- C. NEMA TC 2, UL 651; Schedule 40 and 80 PVC
- D. Fittings: NEMA TC 3, UL 651

2.6 OPTICAL FIBER CABLE RACEWAY AND FITTINGS

- A. Per requirements in Division 27.

2.7 METAL WIREWAYS

- A. NEMA 250, UL 870; galvanized sheet metal troughs with hinged or removable cover, Type 1 for indoor and 3R for outdoor, unless otherwise indicated.
- B. Size: cross section and length as indicated on drawings.
- C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mated with wireways as required for complete system.
- D. Wireways Covers: Screw-cover type for indoor, flanged-and-gasketed type for outdoor.
- E. Knockouts: none.
- F. Finish: Manufacturer's standard enamel finish
- G. Manufacturers: Same as listed in Section 2.9F.

2.8 OUTLET BOXES

- A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A; galvanized steel with stamped knockouts.
 - 1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2" male fixture studs, where required
 - 2. Concrete Ceiling Boxes: Concrete type
 - 3. Communications outlet boxes:
 - 1) Back Box: 5" square, 2-7/8" deep.
 - 2) Provide opening for Division 27 manufacturer bezel or mounting strap.
 - 4. Plaster ring: Match depth to provide flush faceplates.
- B. Cast-Metal Outlet Boxes: NEMA FB 1, cast aluminum or cast iron (galvanized), Type FD, with gasketed cover and threaded hubs
- C. Gangable type boxes are not allowed
- D. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Approved equal

2.9 MULTISERVICE FLOOR BOXES

- A. Above Grade: Stamped steel, watertight design approved for use on above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication services. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.
- B. On Grade: Cast iron or steel pour box, watertight design approved for use in on-grade and above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication devices. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.
- C. Covers: Activation Covers – Die-cast aluminum with textured aluminum finish, and black or brass powder-coated paint finishes as selected by the Architect. Cover: flanged or flangeless, as required, with options for tile or carpet inserts, blank covers, or covers with one or two **27 mm(1")** liquid tight conduit openings for furniture feed applications.
- D. Communication Modules Mounting Accessories: Complete line of faceplates and bezels provided by floor box manufacturer to facilitate mounting of fiber optic, coaxial, high-performance twisted-pair cabling, and communication devices. Cabling type and faceplate configurations per requirements in Section 27 1500 – Communications Horizontal Cabling (if applicable). The box shall accommodate workstation connectivity outlets and modular inserts and other system devices specified in Division 27 specifications. Coordinate mounting inserts, mounting plates, or bezels with Section 27 1500.
- E. Manufacturers:
 - 1. Poke-thrus:
 - a. FSR – SmartFit-8 Complete Series
 - b. Hubbell – SystemOne Series
 - c. Legrand – Evolution Series
 - 2. On-Grade:
 - a. FSR – FL-200 Series
 - b. Hubbell - HBLCFB Series
 - c. Spider - AFB/CFB Series
 - d. Legrand - Evolution Series

2.10 PULL AND JUNCTION BOXES

- A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel
- B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; cast aluminum or galvanized, cast iron with ground flange, gasketed cover and stainless steel cover screws
- C. Minimum size: 4" square by 2-1/8" deep for use with 1" conduit and smaller; 4-11/16" square by 2-1/8" for use with 1-1/4" conduit and larger
- D. Sheet Metal Boxes Larger Than 12" in any direction: Hinged cover or a chain installed between box and cover

1. Sheet metal boxes larger than 24" in any direction: Split hinged cover.
- E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.
- F. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; Hubbell-Weigmann; Hoffman; J&A Sheet Metal Inc. Austin Electrical Enclosures; Approved equal

2.11 EXPANSION FITTINGS

- A. Malleable iron, hot dip galvanized allowing 4" allowing 2" raceway movement.
- B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.D.

2.12 RACEWAY PENETRATION SEALS

- A. Thruwall and Floor Seals.
- B. Manufacturers: New construction – OZ/Gedney FSK Series; existing construction – OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.D.

2.13 RACEWAY SEALING FITTINGS

- A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series; Approved equal
- B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal
- C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound; Approved equal

2.14 CABLE SUPPORTS

- A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.D.

2.15 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends, with integral water stop.
- B. Integral Water Stop: Manufacturer: Thunderline Corporation; Approved equal
 1. High density polyethylene (HDPE). Type Century-Line engineered sleeve with end caps.
 2. Steel. Type WS engineered sleeve.

2.16 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 2. Pressure Plates: Carbon steel. Include two for each sealing element.
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 GENERAL

- A. Division 26 Contractor shall provide all Division 27 pathway infrastructure as specified and shown on plans, including but not exclusive to back boxes, conduits, pull boxes, cable trays, surface raceways, and floor boxes.
 - 1. Coordinate communication outlet opening size and location with Division 27 contractor.

3.2 COORDINATION

- A. Coordinate with Architect/Engineer size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.
- B. Coordinate with Architect/Engineer cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.
- C. Verify with Architect/Engineer all surface raceway installations except in mechanical, electrical, and communications rooms.
- D. Coordinate routing of any through-wall or through-roof conduits.
- E. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
- F. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.
- G. Verify with manufacturer that “touch-up” paint kit are available for use.

3.3 EXAMINATION

- A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway’s installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.4 INSTALLATION

- A. Raceways:
 - 1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
 - 2. Arrange raceways to maintain headroom and present neat appearance.
 - 3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
 - 4. Keep raceways at least 12” away from parallel runs of fuels, steam, hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6’-6” minimum headroom, except in exit pathways 7’-0” minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
 - 5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.
 - 6. Avoid exposed raceway runs. Run raceways exposed where impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel

- or perpendicular to construction. Do not route exposed raceways over boilers or other high-temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.
7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.
 8. Install raceway in structural or topping floor slabs, where noted on plans, as follows:
 - a. Center raceways in structural slabs clear of reinforcing steel, except where crossing same, and spaced on centers equal or exceeding 3 times the raceway diameter. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete.
 - b. Outside diameter of raceway shall not exceed 1/3 the structural slab thickness.
 - c. Obtain approval from Engineer for each run of raceway 1" or larger.
 - d. Do not run raceways through cast-in-place support elements without approval from the structural engineer.
 - e. Do not install raceways in topping slabs of 3" or less.
 - f. Locate raceways to avoid conflict with equipment, door bucks, partitions and other equipment bolted to floor.
 - g. Use concrete tight set screw conduit connectors.
 - h. Arrange stub-ups so curved portions of bends are not visible above finished slab. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; use flexible metal conduit 6" above the floor. Install threaded plugs flush with floor for future equipment connections.
 - i. Change from nonmetallic raceway to RMC or IMC before rising above floor.
 9. Cut raceways square using saw or pipecutter.
 10. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 1", unless sweep elbows required. Bend raceways according to manufacturer's recommendations. Do not use torches or open flame to aid in bend of PVC conduit.
 11. Use raceway fittings compatible with raceways and suitable for use and environment.
 12. Provide bushings on all raceways.
 13. Raceways minimum sizes:
 - a. Minimum raceway size 3/4", except as noted on drawings.
 - b. Minimum homerun size 1", except as noted on drawings.
 - c. Minimum size for flexible metal conduit is 3/4", except as noted on drawings.
 - d. Minimum size for liquidtight flexible metal conduit is 3/4".
 14. All Communications pathway shall be sized for 40% maximum fill, including 50% future growth.
 15. Install empty raceways with 200 lb nylon pull cord; leave at least 12" of slack at each end of pull wire. Cap raceways at both ends.
 16. Feed devices on same wall vertically from above or junction box in suspended ceiling.
 - a. Do not install horizontal bends in conduit around corners.
 17. Raceways Supports:
 - a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
 - b. Raceway supports for horizontal or vertical single runs:
 - 1) Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.
 - c. Raceway supports for horizontal and vertical multiple runs:

- 1) Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.
 - 2) Support horizontal runs with appropriately sized rods.
 - 3) Anchor vertical runs to structure.
 - d. Vertical raceway runs 1-1/4" and larger passing through floors: Support at each floor with pipe riser clamps.
 - e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.
 - f. Secure raceways in metal stud walls to prevent rattling.
 - g. Arrange raceway supports to prevent misalignment during wiring installation.
 - h. Do not fasten raceways to corrugated metal roof deck.
 - i. For fasteners and supports, including steel slotted support systems, support devices, support spacing, support of conductors in vertical raceways, and hanger rod size, refer to Section 26 0529 – Hangers and Supports for Electrical Systems and NFPA 70.
18. Identify raceways per requirements in Section 26 0553 – Electrical Systems Identification.
19. Ground raceways per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
20. Flexible Conduit Connections: Use maximum of 72" of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
- a. Use LFMC in damp or wet locations subject to severe physical damage.
 - b. Do not use LFMC in plenum spaces or within air handling equipment.
 - c. Use FMC in dry locations not subject to severe physical damage.
21. Install stainless steel raceway clamps, mounting hardware, supports, hangers, etc., when located in wet areas.
22. Power and Communications Raceways: Minimum 12" separation when run parallel, cross perpendicular.
23. Communications Raceway Requirements:
- a. All Communications raceways shall conform to industry, BICSI, and UK-CNS standards.
 - b. All voice, data, video wiring inside rooms shall be protected by metallic conduit or other means such as surface raceway or in-floor troughs.
 - c. Bond conduits to cable tray to provide grounding continuity.
 - d. No more than an equivalent of 180 degrees of bend, including offsets, are allowed in a conduit run between junction boxes or pull boxes.
 - e. No "LBS" are allowed.
 - f. Pull boxes shall be provided in conduit runs longer than 100 feet.
 - g. Maximum individual conduit run including a pull box shall not exceed 150 feet.
 - h. All EMT fittings shall be compression type on conduits less than 2-1/2" in diameter.
 - i. Conduits ending at a cable tray shall have plastic bushings and be bonded to the tray.
 - j. Conduits terminating within a Communications room shall have plastic bushings and be bonded to the telecommunication grounding bus bar located in that room.
 - k. Each horizontal communications conduit shall be home-run to the nearest cable tray. No device to device conduit runs are allowed.
 - l. Communications conduit bend radii shall be:
 - 1) Six (6) times the internal conduit diameter for conduit 2" or less internal diameter.

- 2) Ten (10) times the internal conduit diameter for conduit greater than 2" internal diameter.
 - m. Conduit bends shall be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation
- B. Wireways:
1. Install in accordance with manufacturer's instructions.
 2. Use screws, clips and straps to fasten raceway channel to surfaces.
 3. Mount plumb and level.
 4. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
 5. Supports: Per manufacturer's recommendations.
 6. Close ends of raceway channel and unused conduit openings.
- C. Boxes:
1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
 2. Install boxes to accommodate minimum Communications cable bend radii and service loop lengths.
 3. Install each above-ceiling Communications outlet box for immediate accessibility after all trades are installed.
 4. Install the appropriate cover on surface-mounted boxes:
 - a. Raised device covers on 4 square and handy boxes.
 - b. Device covers that are square drawn or square cut on boxes in block.
 - c. Tile covers on boxes in tile.
 - d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
 - e. Set front edge of device boxes flush with finished wall surfaces except on walls of non-combustible materials where boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
 5. Set outlet boxes parallel to construction and independently attached to same.
 6. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls and fire-rated walls.
 - a. All boxes installed in acoustic-rated walls shall be installed with acoustic putty pads.
 7. Conduit penetrations plus inset boxes for panels, receptacles, or other functions shall not derate acoustical integrity of acoustical demising partitions. Provide acoustical sealant or resilient fire caulking for penetrations.
 8. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
 9. Box Support:
 - a. Mount boxes straight.
 - b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
 - c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
 - d. Do not support boxes with tie-wire.

- e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
 - f. Support boxes independently of raceways.
 - g. Install adjustable steel channel fasteners for hung ceiling outlet box.
 - h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
 - i. Do not install boxes to ceiling support wires or piping systems.
10. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
 11. Mount boxes in block walls at block joint nearest to indicated height.
 12. 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.
 13. When boxes are installed in fire-resistive walls and partitions, limit penetrations to 16 sq in per penetration and not to exceed a total of 100 sq in per 100 sq ft of wall area. Use FireBlok fire suppression gaskets or fire stop putty pads acceptable to the fire marshal.
 14. Pull and junction boxes: Install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
 15. Install boxes to be permanently accessible.
 16. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.
 17. Adjust box location up to 10' prior to rough-in to accommodate intended purpose.
 18. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726 – Wiring Devices.
 19. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
 20. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.
- D. Floor Boxes:
1. Set floor boxes level and flush with finished floor surface.
 2. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements, using materials and methods specified in Section 26 0593 – Electrical Systems Firestopping.
- E. Expansion Fittings:
1. Install raceway expansion and deflection fittings in all raceway runs embedded in or penetrating concrete where movement perpendicular to axis of the raceway may be encountered.
 2. Install raceway expansion fittings complete with bonding jumpers in raceway runs that cross expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
 3. Install fitting(s) that provide expansion and contraction for at least 0.0004" per ft of length of straight run per °F of temperature change.
 4. 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.
- F. Raceway Penetration Seals:
1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint.
 3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 0593 – Electrical Systems Firestopping.
 4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
 5. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1" annual clear space between pipe and sleeve for installing mechanical sleeve seals.
 6. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1" annual clear space between raceway and sleeve for installing mechanical sleeve seals.
 7. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 8. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.
 9. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.
- G. Raceway Sealing Fittings:
1. Install listed watertight seals to prevent the passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of the building, where raceway passes between areas of different temperatures such as into or out of cold rooms, freezers and air handling units, where raceway enters room which at any time is subject to low or high temperatures and where raceway enters a room which at any time is subject to internal air pressures above or below normal.
 2. Install watertight seals in interior of all raceways passing through building roof, ground floor slab (when the raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on the end inside building, using raceway sealing fittings manufactured for the purpose. Locate fittings at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank coverplate to match finish of adjacent plates or surfaces.
- H. Raceway and Outlet Box Sealing in Bio-sensitive Areas (including holding rooms, cage wash and other washdown spaces):
1. Where outlet boxes and raceways are recessed mounted, seal box to adjacent wall, ceiling, or floor surface with silicone caulk.
 2. See drawing details for additional raceway and outlet box requirements.
 3. Where outlet boxes and raceways are surface mounted (surface mounting permitted only upon prior approval from A/E):
 - a. Seal box to adjacent wall, ceiling, or floor surface with continuous bead of silicone caulk.
 - b. Seal both sides of surface-mounted raceway to adjacent surfaces with silicone caulk. Where raceways are threaded rigid steel on minimum 3/4" standoffs, sealing of raceway sides is not required.

4. Install gasketed device cover plates with additional continuous bead of silicone caulk between device plate and adjacent wall, ceiling, or floor surface.
 5. After wiring is installed, surround wiring with 1" barrier of silicone caulk around conductors within device box hub.
 6. Silicone or Urethane Caulk: Resistant to microbiological growth. See section 26 0000 for additional product requirements.
 7. No escutcheons are allowed where raceways pass through walls, floors or ceilings and are exposed in finished areas. Cut and patch holes to within 1/4" of raceway and seal opening with sprayable vinyl, flexible PVC coating equal to Cocoon material.
 8. Mockup at least one location with a sample of a completed installation for backbox, wiring and raceway in a holding room for review by Owner, Architect and Engineer prior to installation of other locations.
- I. Sleeve Installation for Electrical Penetrations:
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
 2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
 3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 4. 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.
 5. Cut sleeves to length for mounting flush with both surfaces of walls.
 6. Extend sleeves installed in floors 2" above finished floor level.
 7. Size pipe sleeves to provide 1/2" annular clear space between sleeve and raceway, unless sleeve seal is to be installed.
 8. Communications sleeve requirements:
 - a. Extend Communications sleeves installed in floors 6" above finished floor level.
 - b. Communications floor sleeves shall be rigid metallic conduit.
 - c. Communications floor sleeves shall have threaded bushings on both ends.
 - d. Communications floor sleeves shall be bonded to the Telecommunications grounding busbar.

3.5 APPLICATION

- A. Raceway uses permitted and not permitted per NFPA 70 requirements and as described below.
- B. Rigid Metal Conduit (RMC) permitted to be installed as follows:
1. Installations below grade and in or under concrete slabs
 2. All locations except corrosive atmospheres
 3. Hazardous locations
 4. Locations requiring mechanical protection
 5. Stub up through slabs
- C. Intermediate Metallic Conduit (IMC) permitted to be installed as follows:
1. Installation below grade and in or under concrete slabs
 2. All locations, except corrosive atmospheres
 3. Hazardous locations

4. Locations requiring mechanical protection
- D. Electrical Metallic Tubing (EMT) permitted to be installed as follows:
1. Interior partitions
 2. Above suspended ceilings
 3. In concrete slabs
 4. Above 6 ft AFF in exposed areas of mechanical equipment rooms
 5. Exposed in areas not subject to damage
 6. Sizes 2" and smaller except as approved
- E. Flexible Metal Conduit (FMC) permitted to be installed as follows:
1. Use flexible metal conduit not over 4 ft in length for final connections for:
 - a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in dry locations.
 - b. Final connections to recessed luminaires in lengths not to exceed 6 ft.
- F. Liquid Tight Flexible Metal Conduit (LFMC) permitted to be installed as follows:
1. Use liquid tight flexible conduit, not over 4 ft in length, for final connections to:
 - a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in wet locations.
 - b. Instruments and control devices
 - c. PVC coated LFMC is not allowed in environmental air plenum spaces or air handling equipment.
- G. Rigid Nonmetallic Conduit (RNC) permitted to be installed as follows:
1. Direct burial, concrete encased
 2. Direct burial, in sand fill on bottom and top
 3. Corrosive atmospheres
 4. Use steel elbow in concrete encased runs
- H. One-half inch raceway permitted:
1. Between controller and its control or pilot device
 2. Between lighting switch and nearest outlet for luminaire
 3. Control wiring where mounted on equipment where conduit must follow contour of equipment
 4. Protective and signal systems where noted
 5. Where shown on plans

3.6 RACEWAY WIRING METHODS

- A. Underground: Install galvanized rigid steel conduit or thickwall nonmetallic conduit encased in concrete; threaded conduit fittings for steel; primed and solvent glue fittings for PVC.
- B. In Slab: Install electrical metallic tubing; concrete tight set screw conduit fittings; install cast metal boxes.
- C. Outdoor Locations, Above Grade: Install galvanized rigid steel conduit or intermediate metal conduit; threaded conduit fittings; install cast metal or nonmetallic outlet boxes with threaded hubs.

- D. Wet and Damp Indoor Locations: Install galvanized rigid steel conduit or intermediate metal conduit; threaded conduit fittings; install cast metal or nonmetallic outlet, junction, and pull boxes with threaded hubs. Install flush mounting outlet boxes in finished areas.
- E. Concealed and Exposed Dry Locations Not Subject to Damage: Install electrical metallic tubing; install sheet metal boxes; install flush mounting outlet boxes in finished areas.
- F. Exposed Subject to Damage: Install galvanized rigid steel conduit or intermediate metal conduit; threaded conduit fittings; install cast metal boxes with threaded hubs. Open public spaces such as parking garages and common areas are considered subject to damage.

3.7 FIELD QUALITY CONTROL

- A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.
- B. Replace any damaged component of the raceway system, or install new raceway system.
- C. Inspect components, wiring, connections and grounding.

3.8 REPAINTING

- A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Owner.
- B. Repair damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Owner.

3.9 ADJUSTING

- A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.
- B. Install knockout closures in unused openings in boxes.
- C. Align adjacent wall-mounted outlet boxes for switches and similar devices.
- D. Adjust outlet boxes to allow luminaires to be positioned as indicated on drawings.

3.10 CLEANING

- A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

3.11 LABELING

- A. All labeling shall comply with the published labeling UKPPDMC standard.
- B. Stencil systems pull boxes:
 - 1. Communications as "COMM"

END OF SECTION

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SECTION 26 2726 WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 26 0526 - Grounding and Bonding for Electrical Systems
- B. Section 26 0553 - Electrical Systems Identification

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. Section includes receptacles, hazardous (classified) location receptacles and device cover plates.

1.4 REFERENCE STANDARDS

- A. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- B. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits
- C. IEEE C62.45 – Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits
- D. NECA 1 – Good Workmanship in Electrical Contracting
- E. NFPA 70 – National Electrical Code
- F. NEMA WD-1 – General Color Requirements for Wiring Devices
- G. NEMA WD-6 – Wiring Devices - Dimensional Requirements
- H. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)
- I. UL 498 – Attachment Plugs and Receptacles
- J. UL 943 – Ground-Fault Circuit-Interrupters
- K. UL 1310 – Class II Power Units
- L. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Manufacturer's Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- E. Closeout Submittals:
 1. Project Record Documents:
 - a. Record actual locations and ratings of wiring devices.
 2. Operation and Maintenance Data:
 - a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
 - b. Include source and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

- A. Obtain wiring devices from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.8 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Cooper Wiring Devices; a division of Cooper Industries, Inc.
- B. Hubbell Incorporated; Wiring Device-Kellems
- C. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.2 RECEPTACLES

- A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
- B. Receptacles: 125 V, 20A, heavy-duty (specification grade; side wired; flush mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex configuration unless otherwise noted).
 1. Ground Fault Circuit Interrupter (GFCI):

- a. Additional compliance with UL 943 Class A.
 - b. Leakage current trip level: 4 to 6 mA.
 - c. Trip time: .025 seconds nominal.
 - d. Feed-through type
 - e. Reverse line-load function to prevent GFCI from functioning if wired incorrectly.
 - f. Indicator Light: Lighted when device is tripped.
2. Isolated Ground (IG):
 - a. Ground strap isolated from mounting strap.
 - b. Ground screw connected directly to ground contacts.
 3. USB Charging:
 - a. UL-498 and UL-1310 listed
 - b. Two USB 2.1 Amp or 3.0 Amp, 5VDC charging ports in addition to two 120V, 20A NEMA 5-20R outlets in one single gang device.
 - c. LED indicator for notification of USB port connection.
 - d. Auto-grounding connection type.
 4. Tamper Resistant (TR):
 - a. Requires insertion of object in both left and right contacts to energize.
 - b. 2- or 3-prong plug.
 5. Twist-locking:
 - a. NEMA WD 6 configuration as indicated on drawings.
 6. Switched: Upper half switched and lower half not switched.
 7. Dedicated: Labeled "Dedicated."
 8. Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.

2.3 DEVICE COVER PLATES

- A. Single and combination types to match corresponding wiring devices:
 1. Attachment: Metal screws with head color to match plate finish.
 2. Material for Finished Spaces: satin-finished stainless steel.
 3. Material for Unfinished Spaces: Galvanized steel.
 4. Material for Damp Locations: Cast aluminum with while-in-use hinged cover, and listed and labeled for use in "wet locations."
- B. Weatherproof Cover Plates (Indoor Flush):
 1. Vertical Receptacles: Hubbell HBL5221 or approved equal.
 2. Horizontal Receptacles: Hubbell HBL5206WO or approved equal.
- C. Weatherproof Cover Plates (Outdoor): NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with weatherproof while-in-use hinged cover with tab for locking with padlock.
- D. Tamper Resistant (TR):
 1. Slide cover over receptacle.

2.4 FINISHES

- A. Color:

1. Receptacle faceplates, and device cover plates:
 - a. Receptacle faceplates connected to Emergency Power System: Red.
 - b. UPS Receptacles: Gray

PART 3 - EXECUTION

3.1 COORDINATION

- A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.
- B. Receptacles for Owner-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.
- C. 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 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 device cover plate does not cross a joint
 4. Install wiring devices after all wall preparation, excluding painting, is complete. Install device cover plates after painting is complete.

3.2 EXAMINATION

- A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.
- B. Verify outlet boxes are installed at proper height.
- C. Verify wall openings are neatly cut and completely covered by wall plates.
- D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.3 PREPARATION

- A. Clean debris from outlet boxes.

3.4 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.
- B. 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. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.
- C. Device Installation:
1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
 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 last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6" 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 #10 AWG are installed on 20A circuits, splice #12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
 10. Install devices plumb, level with finished surfaces and free from blemishes.
 11. Install devices above counters, 2" to the bottom of device above countertop or backsplash. Install all devices at same height above any one counter or fixed cabinet.
 12. Install special purpose receptacles according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
 13. Install weatherproof GFCI receptacles:
 - a. Within 25'-0" of roof-mounted mechanical equipment
 - b. Outdoors
 - c. As indicated on drawings
 14. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conductor. Ground per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
- D. Installation Orientations:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
 2. Unless otherwise indicated or where space problem occurs, mount devices flush, with long dimension vertical.
- E. Device Cover Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

3.5 IDENTIFICATION

- A. Comply with Section 26 0553 – Electrical Systems Identification.
1. Receptacles (20A, 120V): Use hot, stamped or engraved machine printing with black-filled lettering on white background on face of cover plate, and durable wire markers or tags inside outlet boxes. Indicate source panel identification and circuit number.
 2. Receptacles (other than 20A,120V): Use hot, stamped or engraved machine printing with black-filled lettering on white background on face of cover plate, and durable wire markers or

tags inside outlet boxes. Indicate source panel identification, circuit number, voltage, phase, and amperage.

3. Emergency Power Receptacles: In addition to above indicate "Emergency".
4. Engrave cover plates on all Owner-furnished equipment and equipment furnished under other divisions of these specifications with source panel identification, circuit number (where applicable) as specified in this section.
5. Provide factory embossed or field-applied label to automatically switched receptacle face or cover plates to comply with ASHRAE 90.1 and NEC 406.3(E). Label is to include symbol indicated below. Use Hubbell CL60 label or equal for field applied labels.



- a. Switched receptacle symbol:

3.6 FIELD QUALITY CONTROL

- A. Inspect wiring devices for defects.
- B. Verify receptacle device is energized.
- C. Perform tests and prepare test reports:
 1. Test receptacle devices for proper polarity:
 - a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
 2. Test each GFCI receptacle device for proper operation:
 - a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. "TEST" button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
 3. Test Instruments: Use instruments that comply with UL 1436.
 4. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
- D. Tests for Convenience Receptacles:
 1. Line Voltage: Acceptable range is 105 V to 132 V.
 2. USB Voltage: Acceptable range is 4.8VDC to 5.5VDC.
 3. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
 4. Ground Impedance: Values of up to 2 ohms are acceptable.
 5. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 6. Using the test plug, verify that the device and its outlet box are securely mounted.
 7. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.

F. Interpret test results in writing and submit to Engineer.

3.7 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.8 CLEANING

A. Remove excess plaster from interior of outlet boxes.

B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

END OF SECTION

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SECTION 26 2816 ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED WORK

- A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 0526 – Grounding and Bonding for Electrical Systems
- C. Section 26 0529 – Hangers and Supports for Electrical Systems
- D. Section 26 0553 – Electrical Systems Identification
- E. Section 26 0812 – Power Distribution Acceptance Tests
- F. Section 26 0813 – Power Distribution Acceptance Test Tables
- G. Section 26 2813 – Fuses

1.2 REFERENCE

- A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

- A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.4 REFERENCE STANDARDS

- A. ANSI//NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- D. NFPA 70 - National Electrical Code
- E. UL 98 - Enclosed and Dead Front Switches
- F. UL 486A - 468B - Wire Connectors
- G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures
- H. UL 869A - Reference Standard for Service Equipment

1.5 SUBMITTALS

- A. Product Data:

1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.
- B. Manufacturer's Installation Instructions:
 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.
- C. Test Reports:
 1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
 1. Project Record Documents:
 - a. Record actual locations of disconnect switches and ratings of installed fuses.
 - b. Record actual locations and continuous current ratings of enclosed circuit breakers.
 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

- A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.
- B. Regulatory Requirements:
 1. Comply with NFPA 70 for components and installation.
 2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.
- B. Comply with manufacturer's written instructions.

1.8 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Square D
- B. General Electric
- C. Cutler-Hammer
- D. Siemens
- E. Erickson Electric Company

2.2 DISCONNECT SWITCHES

- A. NEMA KS 1, UL 98
- B. Load interrupter enclosed knife switch, heavy-duty type.
- C. Fusible or non-fusible type as indicated.
- D. Switch Interiors:
 - 1. Switch blades that are visible in "OFF" position when switch door is open.
 - 2. Plated current carrying parts.
 - 3. Removable arc suppressors to permit easy access to line side lugs.
- E. Switch Mechanism:
 - 1. Quick-make, quick-break, with visible blades and externally operable handle.
 - 2. Lockable only in "OFF" position and accept three industrial type, heavy-duty padlocks.
 - 3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.
 - 4. Defeater mechanism to bypass interlock.
 - 5. Operating handle integral part of enclosure.
 - 6. Handle to physically indicate "ON" and "OFF" position.
- F. Ratings:
 - 1. Ampacity as indicated on drawings.
 - 2. Minimum 10kA withstand rating for non-fusible switches
 - 3. Minimum 100kA withstand rating for fusible switches
 - 4. Horsepower rated.
- G. Fusible Switches:
 - 1. Rejection clips for Class R fuses specified.
 - 2. Provisions for Class J or Class L fuses, as applicable.
 - 3. Fuses: Per requirements in Section 26 2813 – Fuses.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. NEMA AB 1, UL 489.

- B. Enclosed molded-case circuit breakers:
 - 1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF”.
 - 2. 225A frame size and below: thermal-magnetic trip.
 - 3. 250A frame size and above: electronic (solid-state microprocessor-based) trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.
 - 4. Locking tabs on cover to allow breaker handle to be locked in the open or closed position. When locked cover is not allowed to be removed.
- C. Breaker Mechanism:
 - 1. Quick-make, quick-break.
- D. Ratings:
 - 1. Ampacity as indicated on drawings.
 - 2. Listed as Type HACR for air conditioning equipment circuits.
 - 3. Listed as Type SWD for lighting circuits.
 - 4. Interrupting rating as indicated on drawings. Minimum ratings unless otherwise noted:
 - a. 208/120V: 22kA
 - b. 480/277V: 42kA

2.4 LUGS

- A. Front removable lugs.
- B. Labeled for 75°C copper and aluminum conductors.
- C. Multiple lugs to match number of conductors per phase.
- D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

2.5 ACCESSORIES:

- A. Solid neutral assembly, where required.
- B. Equipment ground kit.
- C. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by any type of motor controller including full and reduced voltage starters, solid state soft starters and variable frequency drives.

2.6 ENCLOSURES

- A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.
- B. NEMA Type 1 (dry indoor locations)
 - 1. Code-gauge galvanized steel
 - 2. Manufacturer’s standard gray enamel finish over prime coat
- C. NEMA Type 3R (intermittently wet indoor or outdoor locations)

1. Code-gauge galvanized steel
 2. Manufacturer's standard gray enamel finish over prime coat
- D. NEMA Type 4X (continuously wet or corrosive locations to include cooling towers)
1. Code-gauge Type 316 stainless steel
- E. Surface-mounted

2.7 SHORT CIRCUIT CURRENT RATING

- A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

- A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.
- B. Verify that "touch-up" paint kit is available for repainting.
- C. Provide watertight bolt-on hubs for top entry NEMA-3R and NEMA-4X enclosures.

3.2 EXAMINATION

- A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

- A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.
- B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer's written instruction.
- C. Disconnect switches and enclosed circuit breakers mounting:
1. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 2. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
 3. Install two rows of steel slotted channel, with a minimum of four attachment points, for each disconnect switch and enclosed circuit breaker.
 4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.

- D. Do not support disconnect switches and/or enclosed circuit breakers by raceway.
- E. Install top disconnect switch and/or enclosed circuit breaker handle a maximum of 6'-6" above finished floor.
- F. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A - 486B.
- G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.
 - 1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.
- H. Install fuses in fusible switches at job site per requirements in Section 26 2813 – Fuses.

3.4 CONNECTIONS

- A. Ground equipment according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
- B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

- A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.
- B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.
- C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- D. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7 ADJUSTING

- A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings, as provided by Engineer.

3.8 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 2913 ENCLOSED CONTROLLERS**PART 1 - GENERAL****1.1 RELATED WORK**

- A. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables
- B. Section 26 0526 – Grounding and Bonding for Electrical Systems
- C. Section 26 0529 – Hangers and Supports for Electrical Systems
- D. Section 26 0533 – Raceway and Boxes for Electrical Systems
- E. Section 26 0553 – Electrical Systems Identification
- F. Section 26 0812 – Power Distribution Acceptance Tests
- G.** Section 26 0813 – Power Distribution Acceptance Test Tables
- H. Section 26 2813 – Fuses

1.2 DESCRIPTION

- A. Section includes enclosed manual and magnetic motor controllers and enclosed contactors.
- B. Motors shown on the drawings or specified in other Divisions of these specifications shall be provided with motorized equipment and connected under this section. Provide motor controllers and power circuit disconnect devices for all motors, unless shown or specified to be furnished with motorized equipment under other Divisions of these specifications, and/or by others, for installation by this contract.
- C. Variable-frequency controllers furnished by Division 20 for installation by Division 26.
- D. Motor Voltage Information:
 - 1. Voltages available are: 120V single phase and 460 V, 3-phase. Circuits are designed for motors with voltage ratings as follows:
 - a. Smaller than 1/2 hp motors: 115 V, single phase.
 - b. 1/2 hp motors and larger: 460 V, 3-phase.

1.3 REFERENCE STANDARDS

- A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting
- B. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- C. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)
- D. NEMA ICS 2 – Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 VAC or 750 VDC
- E. NEMA ICS 4 – Industrial Control and Systems: Terminal Blocks

- F. NEMA ICS 5 – Industrial Control and Systems: Control Circuit and Pilot Devices
- G. NEMA ICS 6 – Industrial Control and Systems: Enclosures
- H. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
- I. NEMA MG 1 – Motors and Generators
- J. NFPA 70 – National Electrical Code
- K. UL 98 – Enclosed and Dead Front Switches
- L. UL 486A-486B – Wire Connectors
- M. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures
- N. UL 508 – Industrial Control Equipment

1.4 SUBMITTALS

- A. Product Data:
 - 1. Motor controllers: Submit catalog cut sheets showing voltage, size, rating and size of switching and overcurrent protective devices, dimensions, and enclosure details.
 - 2. Contactors: Submit catalog cut sheets showing voltage, size, current rating, dimensions, and enclosure details.
 - 3. Factory settings and time-current curves of individual protective devices.
 - 4. Confirm motor sizes and voltages with submittals of other Divisions of specifications, and/or by others, prior to Section submittals.
- B. Manufacturer's Installation Instructions:
 - 1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and/or starting of product.
- C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
- D. Closeout Submittals:
 - 1. Project Record Documents:
 - a. Record actual locations and ratings of enclosed motor controllers and enclosed contactors.
 - 2. Operation and Maintenance Data:
 - a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
 - b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.5 QUALITY ASSURANCE

- A. Obtain motor controllers, and contactors from one source and by single manufacturer.
- B. Regulatory Requirements:
 - 1. Comply with NFPA 70 for components and installation.

2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

1.7 WARRANTY

- A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.
- B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.8 MAINTENANCE

- A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
 1. Spare pilot lights: Furnish 1 spare lamp for every 5 installed units, but not less than 1 set of 3 of each kind.
 2. Spare Fuses: Furnish 6 spare fuses for each size installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Square D
- B. General Electric
- C. Cutler-Hammer
- D. Siemens
- E. Allen Bradley

2.2 MANUAL MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for small motors, with bimetal type overload relay and pushbutton operator.

2.3 FULL-VOLTAGE NON-REVERSING MAGNETIC MOTOR CONTROLLERS

- A. Description: NEMA ICS 2, AC general-purpose, Class A, magnetic controller for induction motors rated in horsepower, three-phase and single-phase, as scheduled, except where single-phase motors scheduled to be provided with built-in overload elements:
 1. Size 1 minimum
 2. Control Voltage: 24VAC, 60 Hz
 3. Overload Relays: NEMA ICS 2, solid-state:
 - a. Solid-state type:
 - 1) Class 10, 20 selectable inverse-time tripping characteristics.

- 2) Non-volatile operating memory.
 - 3) 3:1 current adjustment range.
 - 4) Phase loss/phase unbalance protection.
 - 5) Ambient temperature insensitive.
 - 6) Self-powered.
 - 7) Manual reset. Automatic reset not acceptable.
 - 8) Manual trip.
 - 9) Visible trip indication.
4. Features:
- a. Auxiliary Contacts: NEMA ICS 2, 2 each field-convertible contacts in addition to seal-in contact.
 - b. Red mushroom type E-Stop button
 - c. Pilot Lights NEMA ICS 5: push-to-test LED incandescent or LED type. Red for running, green for off.
 - d. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.
 - e. Control Power Transformers: 120V secondary, adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity in each motor controller, but not less than 150VA. Fused primary and secondary, and unfused leg of secondary bonded to enclosure.
 - f. Terminals: NEMA ICS 4.
 - g. Other accessories detailed or required by drawings.

2.4 COMBINATION CONTROLLERS

- A. Factory-assembled motor controllers with externally operable disconnect, fusible switch type, in common enclosure; means for locking disconnect handle and means for defeating cover interlock.
1. Fusible Switch: NEMA KS 1 and UL 98; enclosed knife switch, heavy-duty type, external operable handle, clips or pads to accommodate specified fuses:
 - a. Rejection clips for Class R fuses.
 - b. Provisions for Class J type fuses.

2.5 MOTOR CONTROLLER ACCESSORIES

- A. Factory installed devices in controller enclosure, unless otherwise indicated, as follows:
1. 24 VAC control circuits and pilot light, unless noted otherwise.
 2. Red pilot light to indicate motor operation.
 3. Green pilot light to indicate motor stopped.
 4. Minimum wire size for control circuits: #14 AWG.
 5. Stop and Lockout Pushbutton Station: Momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock pushbutton in depressed position with control circuit open, where indicated.
- B. Control services: As scheduled on motor schedule or indicated.

2.6 LUGS

- A. Labeled for 75°C copper and aluminum conductors.
- B. Multiple lugs to match number of conductors per phase.

- C. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.
- D. For equipment specified in this section and for equipment furnished under other Divisions of this specification and/or by others.

2.7 MOTOR CONTROLLERS AND CONTACTOR ENCLOSURES

- A. NEMA 250, NEMA 1CS 6.
- B. NEMA Type 1, Type 3R (outdoor locations) enclosure.
- C. NEMA-4X for corrosive environments including cooling towers.
- D. Code-gauge galvanized steel.
- E. NEMA-4X enclosure is to be Type 316 Stainless Steel.
- F. Manufacturer's standard gray enamel finish over prime coat.
- G. Surface-mounted.

PART 3 - EXECUTION

3.1 COORDINATION

- A. Coordinate motor control wiring with Division 23 of these specifications.
- B. Coordinate motor sizes and voltages with submittals of other Divisions of these specifications and/or by others.
- C. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.2 EXAMINATION

- A. Examine areas and surface to receive motor controllers and contactors for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Verify that space indicated for motor controllers and contactors mounting meets code-required working clearances.
- C. Notify Architect/Engineer of any discrepancies prior to submittal of product data.

3.3 INSTALLATION

- A. Install motor controllers and contactors in accordance with ANSI/NECA 1.
- B. Install level and plumb, in accordance with manufacturer's written instruction.
- C. Motor controllers and contactors mounting and seismic restraints:
 - 1. Install motor controllers and contactors anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State of Illinois and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.

2. Fasten motor controllers and contactors firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
 3. Anchor and fasten motor controllers and contactors and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
 4. Install two rows of steel slotted channel, with minimum of four attachment points, for each motor controller and contactor.
 5. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
 6. Do not support motor controllers and contactors only by raceway.
- D. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- E. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each motor controller and contactor, using small corrosion resistant metal screws or rivets. Do not use contact adhesive:
1. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.
- F. Connect each motor terminal box to rigid conduit system with maximum 18" of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.
- G. Check for proper rotation and phase relationship of each motor.
- H. Install fuses in fusible switch at job site pre requirements in Section 26 2813 – Fuses.
- I. Control Wiring Installation:
1. Install wiring between motor control devices according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.
 2. Install motor control wiring in accordance with control wiring diagrams and in raceways where indicated or required by contract drawings.
 3. Bundle, train, and support wiring in enclosures.
 4. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - a. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
 - b. Connect selector switches with motor-control 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.

3.4 APPLICATION

- A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, and configuration of pilot device and control circuit affecting controller functions.

3.5 CONNECTIONS

- A. Provide green wire ground through flexible conduit to interconnect motor frame and rigid conduit system.

- B. Ground and bond motor controller and contactor enclosures according to Section 26 0526 – Grounding and Bonding for Electrical Systems.
- C. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.
- D. Connect control wiring for operation, control and supervision of motorized equipment as shown on drawings and/or specified in this and other Divisions of these specifications.

3.6 FIELD QUALITY CONTROL

- A. Inspect motor controllers and contactors for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.
- B. Correct malfunctioning motor controllers and contactors on-site and retest to demonstrate compliance. Remove and replace with new units and retest.
- C. Test continuity of each circuit.
- D. Test motor controllers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.
- E. Interpret test results in writing and submit to Engineer.

3.7 REPAINTING

- A. Remove paint splatters and other marks from surface of equipment.
- B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.8 ADJUSTING

- A. Set field-adjustable circuit breakers trip settings or change the trip settings as indicated on drawings.
- B. Adjust motor circuit protectors.

3.9 CLEANING

- A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

END OF SECTION

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