LITTLETON PUBLIC SCHOOLS

# 2020 CONSTRUCTION STANDARDS VOLUME II

Divisions 21, 22, 23 and 26

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Projects in progress prior to the issue date should refer to the appropriate prior issue

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# DIVISION 21 FIRE SUPPRESSION

## 21 00 00 General Fire Suppression Requirements

- Littleton Public Schools (LPS) Fire Suppression Division 21 provides "Model Specifications" intended to assist consultants develop project specifications
  - Identification of technical requirements or prohibitions, pre-approved manufacturers, and preferred products or models is intended to optimize long-term value to the District and its facilities, balancing innovation and competitive first-cost with manageable standardization and sustainable life-cycle costing
  - The sections are not sufficiently complete to serve as specifications
    - Sections require customization to address conditions, needs and applications for specific projects
    - Detailed collaboration between consultants and LPS managers, technicians, and users is required
    - Proposed deviation requires consultation with and acceptance by the LPS Operations, Maintenance and Construction Department (OMC) and LPS Project Manager (PM)
    - Consultants are responsible for informing the District of any conflict found between the model sections and current codes, standards, or best practices.
- Sprinkler System
  - Supply lines shall be installed overhead, not underground, for easy inspection and drainage.
- Normal Requirement
  - Two (2) hydrants within 500' of maximum risk
  - One (1) within 700' of furthest risk.
  - Investigate basement areas, corridors/exits, auditorium platforms, boiler rooms, and kitchen areas to determine fire protection requirements within the Building(s), as required by the latest edition of applicable Building Code(s).
- Fire Alarm Systems/Extensions
  - Shall match existing system(s) or as otherwise approved by the Littleton Public Schools (LPS) Operations, Maintenance and Construction Department (OMC), LPS Project Manager (PM), and governing fire department

Consultants are required to coordinate with LPS resources including:

Division 27 Technology Design Typicals
Division 28 FA & MN Schematics
Safety and Security Guidelines for Facility Design
Construction Standards Volume 1 for Divisions 00-14 and 31-33
Construction Standards Volume 3 for Divisions 27-28

Resources can be found on LPS Manuals and Regulations web page:
https://littletonpublicschools.net/manuals-regulations

# 21 10 00 Water-Based Fire Suppression Systems

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section specifies automatic sprinkler systems for buildings and structures. Materials and equipment specified in this Section include:

Pipe, fittings, valves and specialties.

Sprinklers and accessories.

B. Products furnished and installed include sprinkler head cabinet with spare sprinkler heads.

C. The work of this section includes engineering by the Contractor. The Contractor shall act as Engineer of record for all fire protection work.

EDIT NOTE: Use the following paragraph for remodels and expansion projects.

D. Where the fire protection system work is an extension of the existing fire protection system, provide all modifications to the existing system as required to complete the new work. Provide hydraulic calculations and shop drawings where required by the extent of the work or by the authority having jurisdiction.

1.2 DEFINITIONS:

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Other definitions for fire protection systems are listed in NFPA Standards 13, 13R, 14, 20 and 24.

C. Working plans as used in this Section means those documents (including drawings and calculations) prepared pursuant to the requirements contained in NFPA 13 and 14 for obtaining approval of the Authority Having Jurisdiction.

1.3 SYSTEM DESCRIPTION:

A. Provide a complete fire sprinkler system for the entire building (including, but not limited to, electrical rooms, mechanical penthouses and accessible sections of air handling units,) except designated areas as shown on the drawings which will not require fire sprinkler coverage will be specifically noted with "No A/S".

B. Fire protection system is a "wet-pipe" system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by fire.

C. Fire protection system is a "dry-pipe" system employing automatic sprinklers attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry-pipe valve. The water then flows into the piping system and out the opened sprinkler.

D. Single Interlocked Preaction System: The single interlocked preaction system requires operation of the detection system to trip the deluge valve and fill the system with water. Water will then be discharged on the fire when the sprinklers fuse. If the sprinkler piping or sprinkler is broken, the valve will not open. If the detection system operates due to fire, damage, or malfunction, the valve will open but the water will be contained in the sprinkler

piping. If the detection system does not operate, the valve will not open. Provide manual release as required by NFPA-13. Detection system and wiring to preaction or fire alarm panel by Division 28.

1. The Preaction System shall be a UL listed assembly.

E. Double Interlocked Preaction System: The double interlocked preaction system utilizes a detector system and pressurized air in the sprinkler piping. This system utilizes the deluge valve and is so arranged that the valve will open only when both pressure reduced in the sprinkler piping and the detection system operates. If the detection system operates due to fire, damage, or malfunction, the valve will not open. If the sprinkler piping is damaged or sprinkler is broken or fused, the valve will not open. The operation of both a sprinkler and a detector (or release) is required before the valve will open allowing water to enter the system piping. The system shall be supervised. Provide manual release as required by NFPA-13. Detection system and wiring to preaction panel or fire alarm panel by Division 28.

F. Fire protection system is a "deluge" system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a fire detection system installed in the same areas as the sprinklers. When this valve opens water flows into the piping system and discharges from all attached sprinklers.

G. Fire protection system is a "Class III, Standpipe and Hose" system which is an arrangement of piping, valves, hose connections and allied equipment.

H. Elevator Shafts and Machine Rooms: Sprinklers shall be installed in elevator machinery rooms, at the top of elevator shafts, and at the bottom of elevator shafts, unless not required.

1. Sprinkler coverage shall be designed for Ordinary Hazard Group One. Sprinkler heads shall be high temperature classification (286 degrees F.).

2. The sprinkler heads in the elevator machinery room shall be supplied from a separate, independent sprinkler branch line with a readily accessible indicating shut-off valve located outside of the shaft or machinery room.

3. At least one smoke detector shall be located in the same area of each sprinkler head. Activation of any one of these detectors shall cause emergency recall (if equipped) of the elevator(s) and also put the building into alarm.

4. In addition to smoke detectors, at least one thermal detector, with 190 degrees F. fixed temperature, shall be installed in the same area of each sprinkler head. The circuitry for the thermal detector(s) shall be separate from the circuitry for the smoke detector(s). When any thermal detector is activated, a shunt-trip circuit breaker shall automatically disconnect all electrical power to the elevator machinery room and the elevator machinery.

5. Division 28 shall provide Fire Detection System (detectors, wiring, panel, etc.) for complete operation of the Fire Sprinkler System for the elevator shaft and machine room.

1.4 PROJECT SEISMIC REQUIREMENTS:

A. Fire protection systems shall be installed to meet NFPA and UBC Seismic Zone 1 requirements.

1. Where any conflicts arise the more stringent requirements shall be applicable.

1.5 SUBMITTALS:

A. Product data for each type sprinkler head, valve, piping and piping specialty, fire protection specialty, fire department connection and any equipment installed in accordance with the Contract Documents. Index per specification chapter and item number.

B. Shop drawings prepared in accordance with NFPA 13 identified as "working plans," including detailed riser schematics indicating pipe sizes and lengths; and hydraulic calculations where applicable, which have been approved by the authority having jurisdiction. Do not proceed with the installation of the work until the Architect/Engineer review of shop drawings is received.

C. Contractor shall stamp shop drawings indicating compliance with applicable codes and contract drawings. Contractor shall stamp drawing "Approved for Construction."

D. If more than two submittals (either for shop drawings or for record drawings) are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the contractor.

E. Maintenance data for each type sprinkler head, valve, piping specialty, fire protection specialty, fire department connection and hose valve specified, for inclusion in operating and maintenance manual specified in the LPS General Conditions of the Contract and Section 23 05 00 "Basic Mechanical Requirements."

F. Welder's qualification certificate.

G. Test reports and certificates including "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Materials and Test Certificate for Underground Piping" as described in NFPA 13.

H. Hydraulic calculations and drawings submitted to the Engineer shall be prepared under the direct supervision of and bear the signed stamp of a professional engineer registered in the State of Colorado and familiar with this type of installation and with previous similar experience (practicing in the Fire Protection field) certifying that the fire sprinkler system has been designed and hydraulically calculated in compliance with NFPA and governing codes.

I. Fire sprinkler piping design drawings shall show all ductwork, air devices, lighting and electrical panels.

J. Shop drawings and hydraulic calculations shall be stamped and signed by the local fire prevention authority prior to submitting shop drawings to the Architect/Engineer.

1.6 HYDRAULIC DESIGN:

A. The Fire Sprinkler System shall be hydraulically calculated by the Contractor. Pipe schedule method is acceptable only as allowed in NFPA 13 5-2.2.

B. The wet pipe fire sprinkler system for the building shall be hydraulically calculated to comply with NFPA-13 and the following criteria:

1. Light hazard occupancy for areas unless noted otherwise.

2. Ordinary hazard occupancy for the following:
   a. Where noted or shown on drawings.

b. Commercial Kitchens
c. Library Stack Areas

3. Hose allowance shall comply with NFPA-13.

C. Final fire protection system demand shall be a minimum of 10 PSI below the water supply curve.

D. Velocities in pipes shall be shown on hydraulic calculations. Velocities in overhead piping shall not exceed 32 feet per second. Velocities in underground piping shall not exceed 16 feet per second (see 21.10.00).

E. Allow 10 feet of loss for electric water flow switches and note on hydraulic calculations.

F. The Fire Protection Contractor shall provide as many sets of hydraulic calculations as necessary, performed and submitted to prove that the most remote and demanding areas are calculated.

G. Design information shall be permanently affixed to the main riser as described in NFPA Pamphlet 13.

H. Water flow data for bidding purposes only is:

[ ]psi static
[ ]psi residual with [ ] gpm flowing

I. The Fire Protection Contractor shall be responsible for water flow data from the appropriate water department. A copy of the water flow test data from the water department shall accompany the hydraulic calculations before hydraulically calculating equipment fire sprinkler system.

J. The pipe and valve sizes indicated on the drawings and details are minimum sizes to be used regardless of sizes allowed by hydraulic calculations.

1.7 QUALITY ASSURANCE:

A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by qualified installer. The term qualified means experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with all precautions required, and has complied with all the requirements of the authority having jurisdiction. The contractor shall be licensed for the design and installation for the specific type of system in the jurisdiction where the work is to be performed and the State of Colorado. Upon request, submit evidence of such qualifications to the Engineer. Refer to the LPS General Conditions of the Contract and other Division 21 sections for minimum requirements for "Installers."

B. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, Specifications of Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."

C. Regulatory Requirements: Comply with the requirements of the following codes:

1. NFPA 13 - Standard for the installation of Sprinkler System, including applicable seismic requirements.
2. NFPA 13R - Standard for the Installation of Sprinkler Systems in residential occupancies up to four stories.

3. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems.
4. NFPA 24 - Installation of Private Fire Service Mains and their applications.
5. NFPA 1961 - Standard for Fire Hose.
6. NFPA 1963 - Screw Threads and Gaskets for Fire Hose Connections.

EDIT NOTE: Verify with Owner insurance requirements to specify FM or IRI.

7. UL and FM Compliance: All fire protection system materials and components shall be Underwriter's Laboratories and Factory Mutual listed as well as labeled for the application anticipated.
8. National Electrical Code (NEC).
9. Uniform Building Codes, including applicable seismic requirements.
10. Requirements of the local Building Department and Fire Department.

D. Reference and standards listed are minimum requirements. Where more stringent requirements are specified or noted on the drawings, this shall be applicable.

1.8 SEQUENCING AND SCHEDULING:

A. Schedule rough-in installations with installations of other building components.

B. Minimum time frame for notice of inspections, tests and meetings is five (5) days and list the persons to be notified.

1.9 EXTRA STOCK:

A. Heads: For each style and temperature range (and length for dry heads) required, furnish additional sprinkler heads per NFPA-13.

1. Obtain receipt from Owner that extra stock has been received.

B. Wrenches: Furnish 2 spanner wrenches for each type and size of valve connection and fire hose coupling.

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS:

A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements.

Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in fire protection systems.

B. All equipment used on this project shall be new and UL listed unless noted or specified otherwise.

2.2 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide fire protection system products from one of the following:

1. Gate Valves:
   a. Central
   b. Automatic
   c. Grinnell Valve Co., Inc.
   d. Nibco

e. Kennedy Valve, Div. of ITT
f. Mueller
g. Stockham
h. Milwaukee
i. Misson
j. Firematic

2. Swing Check Valves:
   a. Central
   b. Viking
   c. Grinnell Valve Co., Inc.
   d. Nibco
   e. Kennedy Valve, Div. of ITT
   f. Mueller
   g. Stockham
   h. Milwaukee
   i. Star Sprinkler Company
   j. Victaulic
   k. Globe
   l. Potter Roemer

3. Butterfly and Ball Valves:
   a. Grinnell
   b. Mueller
   c. Victaulic
   d. Milwaukee
   e. Kennedy

4. Grooved Mechanical Couplings:
   a. Central Sprinkler, Inc.
   b. Gruylock
   c. Victaulic Company of America

5. Double Check Valve Assembly:
   a. Febco Model 850
   b. Watts Model 709
   c. Conbraco 40-100
   d. Ames Model 2000 (epoxy)

EDIT NOTE: When using reduced pressure backflow preventer, provide large floor sink. See code book and manufacturer's data for capacities.

6. Compact Double Check Assembly:
   a. Febco Model 870/870V

7. Reduced Pressure Backflow Assembly:
   a. Febco Model 860
   b. Watts 909
   c. Conbraco 40-200
   d. Ames 4000 Rp (epoxy)

8. Compact Reduced Pressure Backflow Assembly:
   a. Febco Model 880/880V

9. Fire Protection Specialty Valves
   a. Grinnell/Gem
   b. Central

c. Reliable Automatic Sprinkler Co., Inc.
d. Viking Corporation
e. Globe
f. Star Sprinkler Corporation

10. Fire Department Connection:
    a. Croker
    b. Potter-Roemer
    c. Standard
    d. Elkhart
    e. Grinnell/Gem

11. Sprinkler Heads:
    a. Central Sprinkler Corp.
    b. Automatic Sprinkler Corp. of America.
    c. Reliable Automatic Sprinkler Co., Inc.
    d. Viking Corp.
    e. ITT Grinnell
    f. Star Sprinkler Corp.
    g. Globe

12. Fire Protection Specialties:
    a. Grinnell Fire Protection Systems Co., Inc.
    b. Croker-Standard Div., Fire-End & Croker Corp.
    c. Elkhart Brass Mfg. Co., Inc.
    d. Gruneau Sprinkler Mfgr. Co., Inc.
    e. Potter Roemer, Inc.

13. Inspector's Test and Drain Module
    a. Grinnell/Gem
    b. Victaulic
    c. A.G.F.

2.3 BASIC IDENTIFICATION:

A. General: Provide identification complying with Section 23 05 53 "Mechanical Identification", in accordance with the following listing:

1. Fire Protection Piping: Pipe markers.
2. Fire Protection Valves: Valve tags.
3. Fire Protection Signs: Provide the following signs:
    a. At each sprinkler valve, sign indicating what portion of system valve controls.
    b. At each outside alarm device, sign indicating what authority to call if device is activated.
    c. At door to each sprinkler control valves or at ceiling access points, sign reading "FIRE CONTROL".
    d. At each drain or test, sign indicating its purpose.

B. Attach to the riser a metal sign indicating the name, address and telephone number of the fire protection contractor. Also indicate the date of installation.

2.4 BASIC PIPING SPECIALTIES:

A. General: Provide piping specialties complying with Section 23 05 00 Basic Mechanical Requirements section "Piping Specialties", in accordance with the following listing:

1. Pipe escutcheons.

2. Dielectric unions (not allowed at LPS).
3. Drip pans.
4. Pipe sleeves.
5. Sleeve seals.
6. Fire Barrier Penetration Seals.

2.5 BASIC SUPPORTS AND ANCHORS:

A. General: Provide supports and anchors complying with Section 23 05 29 "Supports and Anchors" in accordance with the following listing:

1. Adjustable steel clevis hangers, adjustable steel band hangers, or adjustable band hangers, for horizontal-piping hangers and supports.

2. Two-bolt riser clamps for vertical piping supports.

3. Steel turnbuckles and malleable iron sockets for hanger- rod attachments.

4. Concrete inserts, top-beam C-clamps, side beam or channel clamps or center beam clamps for building attachments.

5. Concrete inserts and other type hangers penetrating into or through structural members shall be submitted (by the Fire Protection Contractor) to and have the approval of the structural engineer contracted for this project.

6. Powder driven studs shall not be allowed.

7. Hangers (which are acceptable for project) and hanger spacing shall be in accordance with NFPA-13.

2.6 PIPE & FITTINGS (UNDERGROUND) (see 21.10.00):

A. Underground pipe shall be ductile iron, thickness Class 52 unless specified otherwise by local authorities or ANSI/AWWA C150/A21.50-81; 350 psi pressure rating; tar coated outside, cement mortar lined inside in accordance with ANSI/AWWA C104/A21.4-80. Full lengths of pipe shall be utilized to the greatest extent possible.

B. Fittings for ductile iron pipe shall be 250 psi pressure rating in accordance with ANSI/AWWA C110-77, tar coated outside and cement lined inside in accordance with ANSI/AWWA C104/A21.4-80.

C. Joints shall be push-on or mechanical type as per ANSI/AWWA C111/A21.11-80.

2.7 PIPE AND TUBING MATERIALS (INSIDE BUILDING):

A. General: Refer to Part 3 Article "Pipe Applications" for identification of systems where the below specified pipe and fitting materials are used.

B. Steel Pipe: ASTM A 53, A795 or A135, Schedule 40 or Schedule 10, U.S. manufacture, black steel pipe, plain ends.

C. American Tube Company "Dyna-Thread-40" and "Dyna-Flow" and Allied Tube and Conduit Corporation "Super Flo" are acceptable to Schedule 40 pipe. Installation shall be per manufacturer's recommendations.

D. Schedule 5 pipe shall not be allowed.

E. The Corrosion Resistance Ratio of the pipe shall be 1.00 or greater. Documentation shall be presented with product submittal.

F. Schedule 10 pipe shall only be allowed for pipe sizes 2-1/2inches and larger.

G. Provide galvanized, schedule 40, piping system for preaction system and drain risers.

2.8 FITTINGS (INSIDE BUILDING):

A. Cast-Iron Threaded fittings: ANSI B16.4, Class 125 standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1.

B. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 300, standard pattern, for threaded joints. Threads shall conform to ANSI B1.20.1. Install steel pipe with threaded joints and fittings for 2inches and smaller and where shown on drawings.

C. Steel Fittings: ASTM A234, seamless or welded, for welded joints.

D. Grooved Mechanical Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47 Grade 32510 malleable iron; or ASTM A53, Type F or Types E or S.

E. Grooved Mechanical Couplings: Consist of ductile or malleable iron housing, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure roll- grooved pipe and fittings. Grooved mechanical couplings including gaskets used on dry-pipe systems shall be listed for dry-pipe service.

F. Grooved Mechanical Fittings and Couplings for the entire fire protection system shall be of the same manufacturer as submitted in shop drawing equipment review.

G. Cast-Iron Threaded Flanges: ANSI B16.1, Class 250; raised ground face, bolt spot faced.

H. Cast Bronze Flanges: ANSI B16.24, Class 300; raised ground face, bolt holes spot faced.

I. Plain end, hooker type, or push-on fittings or couplings shall not be allowed.

J. Bushings and reducing couplings shall not be allowed.

K. UL listed and Factory Mutual approved segmentally welded fittings are acceptable. Friction loss and flow data shall accompany hydraulic calculations.

2.9 JOINING MATERIALS:

A. Welding Materials: Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

B. Gasket Materials: Thickness, materials and type suitable for fluid or gas to be handled, and design temperatures and pressures.

2.10 GENERAL DUTY VALVES:

A. Gate Valves - 2 Inch and Smaller: Body and bonnet of cast bronze, 175 pound cold water working pressure - non-shock, threaded ends, solid wedge, outside screw and yoke, rising stem, screw-in bonnet, and malleable iron hand-wheel. Valves shall be capable of being repacked under pressure, with valve wide open.

B. Gate Valves - 2-1/2 Inch and Larger: Iron body; bronze mounted, 175 pound cold water working pressure - non-shock. Valves shall have solid taper wedge; outside screw and yoke, rising stem; flanged bonnet, with body and bonnet conforming to ASTM A 126 Class B; replaceable bronze wedge facing rings; flanged ends; and a packing assembly consisting f a cast iron gland flange, brass gland, packing, bonnet, and bronze bonnet bushing. Valves shall be capable of being repacked under pressure, with valve wide open.

C. Butterfly Valves: 2-1/2inches to 12inches, grooved, ductile iron body and disc ASTM-536, disc EPDM coated, listed and approved minimum 175 psi service, actuator, self-contained supervisory switch, weatherproof approved for indoor or outdoor use.

D. Ball Valves: 1-1/2inches and smaller shall be threaded, forged brass construction, with teflon seats and blow out proof stem. Ball shall be full port with chrome plated ball.

E. Ball Valves: 2inches to 3inches, shall be listed to 300 psi with optional internal tamper switch. Body shall be ductile iron with corrosion resistant coating. Ball shall be 316 stainless steel, standard port design.

F. Swing Check Valves: MSS SP-71; Class 175, cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

G. Double Check Valve Assembly: Double check valve assembly shall be UL listed for fire protection service and USC-CCCF approved. Installation arrangement shall be per manufacturer's recommendations.

H. Provide reduced pressure backflow preventer where required by authority having jurisdiction and/or water department having jurisdiction. See Part 2 Products under this Section for acceptable manufacturers and model number.

2.11 SPECIALTY VALVES:

A. Dry-Pipe Valves: Differential type, 175 psig working pressure, and have cast iron, flanged inlet and outlet, bronze seat with "O" ring seals, single hinge pin and latch design. Provide trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment and fill line attachment.

B. Air-Pressure Maintenance Device, Dry-Pipe Systems: An automatic device to maintain the correct air pressure in a dry-pipe system or deluge system. System shall have shut- off valves to permit servicing without shutting down the sprinkler system, bypass valve for quick system filling, pressure regulator or switch to maintain system pressure, strainer; pressure ratings 14 to 60 psig adjustable range, and 175 psig maximum inlet pressure. Electrical ratings shall match compressor ratings.

C. Deluge Valves: Cast iron body, 175 psig working pressure, hydraulically operated, differential pressure type valve. Valves shall have flanged inlet and outlet and bronze seat with "O" ring seals. Provide trim sets for bypass, drain, electric sprinkler alarm switch, pressure gauges, drip cup assembly piped without valves separate from main drain line, fill line attachment with strainer and push rod chamber supply connection.

D. Emergency Pull Box: Metal enclosure, labeled with "Manual Emergency Station" and operating instructions, complete with union, 1/2 inch pipe nipple and bronze ball valve. The enclosure cover shall be held closed by a breakable strut, which prevents accidental opening and must be replaced after each opening.

E. Preaction Valves: Preaction systems shall have valves specifically listed for preaction service.

F. Deluge/Preaction System Control Panel: Panels shall be single-area, two-area, or single-area cross-zoned type as indicated. Control panel shall consist of a NEMA 1 enclosure, and contains detector, alarm and solenoid valve circuitry for operation of deluge valves. Panels shall contain power supply, battery charger, standby batteries, field wiring terminal strip, electrically supervised solenoid valves and polarized fire alarm bell, lamp test facility, SPDT auxiliary alarm contacts and rectifier. Control panel shall be UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics shall be 120 volts AC, 60 Hz, with 24 volts DC Gel Cell batteries. Panel provided by Division 21. Wiring from Fire Alarm Panel and power to Control Panel by Division 26. Locate Control Panel alongside Fire Alarm Panel.

2.12 BASIC METERS AND GAUGES:

A. General: Provide meters and gauges complying with Section 23 05 19 "Meters and Gauges", in accordance with the following listing

1. Pressure gauges, 0-250 psi range.

2.13 ALARM DEVICE AND FIRE PROTECTION SPECIALTIES:

A. General: Provide fire protection specialties, UL-listed, in accordance with the listing. Provide sizes and types which mate and match piping and equipment connections.

B. Water Flow Indicators: Vane type water flow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 volts DC; complete with factory-set field-adjustable retard element to prevent false signals, and with activation time retarding capability set at 90 seconds. The setting shall be verified through the inspectors test prior to final inspection.

C. Supervisory Switches: Provide products recommended by manufacturer for use in service indicated. SPST, normally closed contacts, designed to signal valve in other than full open position.

D. Pressure Switch: Indicating low pressure trouble in sprinkler system.

E. Pressure switch: Indicating flow in sprinkler system.

F. Low Air Pressure Horn: Provide low air pressure horn as indicated.

2.14 AUTOMATIC SPRINKLERS:

A. Sprinkler Heads: Fusible link or frangible bulb type, and style as indicated or required by the application. Unless otherwise indicated, provide heads with nominal 1/2 inch discharge orifice, for "ordinary" temperature range with a minimum temperature of 155 degrees F. Provide "intermediate" temperature heads in Electrical rooms, where required as noted in NFPA 13, and as required by the Authority having jurisdiction.

B. Sprinkler Head Finishes: Provide heads with the following finishes:

1. Upright, Pendent and Sidewall Styles: Factory brass, rough bronze finish for heads in unfinished spaces. Heads shall be stainless steel where installed exposed to acids, chemicals, or other corrosive fumes.

2. Concealed Style: Rough brass, adjustable, with painted white cover plate in finished spaces. (GEM Models FR946 and F946 Clean Line Sprinklers are not acceptable.)

3. Recessed Style: Bright chrome, with bright chrome escutcheon plate. GEM Models FR948 and F948 recessed sprinklers are not acceptable.

4. See drawings for additional sprinkler type requirements.

C. Sprinkler Head Cabinet and Wrench: Finished steel cabinet, suitable for wall mounting, with hinged cover and space for spare sprinkler heads plus sprinkler head wrench. Provide amounts of each style per NFPA-13. Locate head cabinet on shop drawing submittal.

D. Plastic fire sprinkler escutcheons are not acceptable.

2.15 FIRE HOSES AND RACKS:

EDIT NOTE: Use para. A for Class I standpipe systems, para. B for Class II standpipe systems, para. C for Class III standpipe systems in a fully sprinklered building, and both A and B for Class III standpipe systems in a non-sprinklered building or where required by the AHJ. Some may require 1- 1/2inch valve outlet even if no hose is required; some may require both a 1-1/2inch and 2-1/2inch valve. Use pressure regulating valves only where system pressure exceeds 100 psig for 1-1/2inch valve or 175 psig for 2-1/2inch valve.

A. Hose Outlet Valves: 300 psig, 2-1/2 inch, rough chrome plated, pressure regulating, brass angle valve with external threads having the local fire department standard thread, for the 2-1/2 inch valve, as specified in NFPA 1963. Provide with cap and chain finished to match valve.

OR

B. Hose Outlet Valves: 300 psig, 1-1/2 inch, rough chrome plated, pressure regulating, brass angle valve with external threads having the local fire department standard thread, for the 1-1/2 inch valve, as specified in NFPA 1963. Provide with cap and chain finished to match valve.

OR

C. Hose Outlet Valves: 300 psig, 2-1/2 inch, rough chrome plated, pressure regulating, brass angle valve, with removable, 2-1/2 inch x 1-1/2 inch reducing lug pin and hose connector coupling. Valve and coupling shall have external threads having the local fire department standard thread, for the 2-1/2inch valve, as specified in NFPA 1963. Provide spanner wrench for removal of reducing coupling. Provide with cap and chain finished to match valve.

EDIT NOTE: Verify requirement for hose and rack. Most AHJs do not want building-supplied hose. Also, edit 2.16 appropriately.

D. Fire Hoses: 100 foot long, 1-1/2 inch, lined linen hose with pin lug, chrome plated, quick disconnect coupling; and chrome plated brass fog nozzle spray pattern adjustable from shut-off directly to 50 degrees fog, through 90 degrees fog. Comply with the requirements of NFPA 1961.

E. Hose Rack: Semiautomatic, steel rack, finished in red enamel, and holds hose in place with cadmium plated pins. Racks shall be secured to the outlet valve and a pivot for release of hose.

EDIT NOTE: Below is a cabinet for 1-1/2inch valve, 2-1/2inch valve, extinguisher and no hose. Edit as appropriate.

2.16 HOSE, VALVE AND EXTINGUISHER CABINETS:

A. General: Provide cabinets to house hose valves [hoses] [and extinguishers] as indicated.

B. Construction: Manufacturer's standard enameled steel box, with trim, frame, door and hardware to suit cabinet type, trim style, and door style indicated. Weld all joints and grind smooth. Miter and weld perimeter door frames.

C. Cabinet Type: Suitable for mounting conditions indicated, of the following types:

1. Recessed (FVC-1): Cabinet box (tub) fully recessed in walls of sufficient depth to suit style of trim indicated.

2. Surface-Mounted (FVC-2): Cabinet box (tub) fully exposed and mounted directly on wall.

D. Provide fire valve cabinet of type indicated with [full glass panel] [solid panel] door.

E. Provide standard equipment "Croker" Series 2750, or "Potter Roemer" Series 1880 valve and extinguisher cabinets.

2.17 ROOF MANIFOLD:

A. Provide [2] [3] way cast brass angle body, male outlets. Provide with [2] [3] hose angle valves (2-1/2inch), cast brass body, female inlet x male outlet, caps and chains, 300 psig rated. Manifold and valves shall have rough brass finish.

2.18 FIRE DEPARTMENT CONNECTIONS:

A. Wall Type Siamese Connections: Polished chrome cast brass, 2-way flush wall type, with wall escutcheon and having National standard threads, for the connections size indicated, as specified in NFPA 1963. Each inlet shall have a clapper valve, and cap and chain. Unit shall have wall escutcheon of cast brass, finish to match connections, with words "Standpipe - Fire Dept. Connection" or "Auto Spklr. - Fire Dept. Connection" or "Auto Spklr. and Standpipe - Fire Department Connection" in raised letters. Contractor shall verify threads with local fire department.

B. Sidewalk Siamese Connection: Polished Chrome plated cast brass, angle body, two way, siamese connection. Connection sizes shall be 4 inch outlet and two 2-1/2 inch inlets, having NH standard threads, for the connection size indicated, as specified in NFPA 1963. Each inlet shall have a clapper valve, and cap and chain. Provide 18 inch high chrome plated brass sleeve and chrome plated brass sidewalk plate, with words "Standpipe - Fire Dept. Connection" or "Auto Spklr. - Fire Dept. Connection" or "Auto Spklr. and Standpipe - Fire Department Connection" in raised letters.

C. Fire department connections including location shall meet the approval of the fire department having jurisdiction.

2.19 INSPECTOR'S TEST AND DRAIN ASSEMBLY:

A. Provide an alarm test module of a manufacturer listed in paragraph 2.2.

B. Comply with NFPA-14, Section 5-11, for draining and testing of wet standpipe system.

C. Test and drain piping shall be routed to exterior. Location shall meet Owner's approval.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine rough-in for fire hose valves and cabinets to verify actual locations of piping connections prior to installing cabinets.

B. Examine walls for suitable conditions where cabinets are to be installed.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE APPLICATIONS:

A. Install Schedule 40 steel pipe with threaded joints and fittings for 2 inch and smaller.

B. Install Schedule 40 steel pipe with roll-grooved ends and grooved mechanical coupling or with threaded joints and fittings.

C. Acceptable alternates to Schedule 40 pipe shall be installed per manufacturer's recommendations.

3.3 PIPING INSTALLATIONS:

A. Provide a minimum 5feet-0inches cover for all underground pipe installations (see 21.10.00). Install in accordance with AWWA C600.

B. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. So far as practical, install piping as indicated. Drawings are diagrammatic in character and do not necessarily indicate every required offset, valve, fitting, etc.

1. Deviations from approved "working plans" for sprinkler piping, require written approval of the Authority Having Jurisdiction. Written approval shall be on file with the Engineer prior to deviating from the approved "working plans."

C. Install sprinkler piping to provide for system drainage in accordance with NFPA 13.

D. Use approved fittings to make all changes in direction, branch takeoffs from mains, and reductions in pipe sizes. Welded outlet branch pipe fittings are acceptable.

E. Install unions in pipe 2 inch and smaller, adjacent to each valve. Unions are not required on flanged devices or in piping installations using grooved mechanical couplings.

F. Install flanges or flange adapters on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

G. For welded pipe, all cutouts (coupons) shall be removed prior to installation.

H. Hangers and Supports: Comply with the requirements of NFPA 13. Hanger and support spacing and locations for piping joined with grooved mechanical couplings shall be in accordance with the grooved mechanical coupling manufacturer's written instructions, for rigid systems. Provide protection from damage where subject to earthquake in accordance with NFPA 13.

I. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.

J. Install mechanical sleeve seal at pipe penetrations in basement and foundation walls. Refer to Section 23 20 00 "Basic Piping Materials and Methods."

K. All piping penetrating walls to structure shall be sleeved and sealed per Section 20 05 18.

L. Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

M. Install pressure gauge on the riser or feed main at or near each test connection. Provide gauge with a connection not less than 1/4 inch and having a soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and where they will not be subject to freezing.

N. The fire line entry valves shall have monitoring electrical switches, the wiring from which shall be carried to the fire annunciating panel.

O. The fire protection contractor shall be responsible for the coordination of his installation with all other contractors. See Section 23 05 00 for prioritized components.

P. Protect adjacent area where pipe cutting and threading takes place (e.g. floors, ceilings, walls, etc.).

Q. There shall be no fire sprinkler piping in electrical rooms (other than piping serving sprinklers directly in that room) or installed over any electrical panels.

R. Provide spring-loaded check valve at top of drain risers.

S. Install pressure gauges on city and system sides of fire entry valve assembly.

T. Install hangers straight and true and piping parallel to building lines.

3.4 PIPE JOINT CONSTRUCTION:

A. Welded Joints: AWS D10.9, Level AR-3.

B. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.

2. Align threads at point of assembly.

3. Apply appropriate tape or thread compound to the external pipe threads.

4. Assemble joint to appropriate thread depth. When using a wrench on valves place the wrench on the valve end into which the pipe is being threaded.

5. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

C. Flanged Joints: Align flange surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

D. Mechanical Grooved Joints: Roll grooves on pipe ends dimensionally compatible with the couplings.

E. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.

3.5 VALVE INSTALLATIONS:

A. General: Install fire protection specialty valves, fittings and specialties in accordance with the manufacturer's written instructions, NFPA 13 and the authority having jurisdiction.

B. Gate Valves: Install electronically supervised-open indicating valves so located to control all sources of water supply except fire department and roof manifolds connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve. Refer to Division-15 Section "Mechanical Identification" for valve tags and signs.

C. Valve at water main tap shall be underground gate valve with roadway box.

D. Install approved check valve assembly reduced pressure backflow preventer in each water supply connection. Provide check valve and indicating valve (with tamper switch) on the discharge side of reduced pressure backflow preventers.

E. Dry-Pipe Valves: Install in the vertical position, in proper direction of flow, in the main supply to the dry- pipe system. Install the basic trim set, priming chamber attachment and fill line attachment in accordance with the manufacturer's written instructions. During hydrostatic test of system piping at pressure in excess of 50 psi, position the clapper in latched wide open position or removed from valve, to prevent injury to the valve. Test valve for proper operation.

F. Deluge Valves: Install in the vertical position, in proper direction of flow, in the main supply to the deluge system. Install the basic trim set in accordance with the manufacturer's written instructions. Connect system controls and test valve for proper operation.

G. Hose Outlet Valves: Install 1-1/2 inch hose outlet valves at each standpipe outlet for hose connections for use by building occupants. Install 2-1/2 inch hose outlet valves at each standpipe outlet for hose connections for use by the fire department.

OR

H. Hose Outlet Valves: Install 2-1/2 inch hose outlet valves with easily removable 2-1/2 to 1-1/2 inch reducing coupling at each standpipe outlet for hose connections.

3.6 SPRINKLER HEAD INSTALLATIONS:

A. Any sprinkler heads with any paint on them shall be replaced. The sprinkler system shall then be hydrostatically tested again at the contractor's expense.

B. Sprinkler heads shall be positioned so as to comply with NFPA-13 for any obstructions. This includes, but is not limited to, soffits, surface mounted lights and indirect lighting arrangements. The Fire Protection Contractor is responsible for identifying these obstructions and designing the system accordingly.

C. Run piping concealed above heated furred ceilings and in joists to minimize obstructions. Expose only heads.

D. Protect all exposed sprinkler heads against mechanical injury with standard guards. Provide sprinkler head guards in all mechanical, electrical or storage rooms as well as exposed pendant heads which are installed less than 8feet-0inches A.F.F.

E. Provide 1 inch diameter nipple and 1 inch x 1/2 inch reducing fitting for each upright head. (Excluding mechanical equipment rooms.)

F. Provide heads in "pocketed" areas caused by exposed duct, piping or beams.

G. Sprinkler head deflector distance from face of finished ceiling shall not exceed 4inches.

H. Sprinkler heads shall be located in the center of all 2 foot x 2 foot ceiling tiles and quarter points, along the center line lengthwise of 2 foot x 4 foot ceiling tiles.

I. Use proper tools to prevent damage during installations.

J. Install sprinkler piping in a manner such that mechanical equipment, ceiling tiles or lights can be accessed and easily removed. The sprinkler piping shall be installed to provide a minimum of 6inches above the top of a finished ceiling.

K. Minimum fire sprinkler head temperature rating for sprinklers in electrical rooms shall be 212 degrees F. Keep sprinklers as far from transformers and/or panels as spacing allows.

3.7 FIRE VALVE CABINET INSTALLATIONS:

A. Install fire hose valve and extinguisher cabinets in locations and at mounting heights indicated, or if not indicated, at heights to comply with applicable regulations of governing authorities.

1. Prepare recesses in walls for cabinets as required by type and size of cabinet and style of trim and to comply with manufacturer's instructions.

2. Securely fasten fire hose valve and cabinets to structure, square and plumb, to comply with manufacturer's instructions.

3. Where exact location of surface-mounted cabinets is not indicated, locate as directed by Architect.

B. Identify equipment in cabinet with lettering spelling "Fire Hose," "Fire Hose and Extinguisher," and "Fire Hose Valve and Extinguisher" applied to door by process indicated below. Provide lettering to comply with requirements indicated for letter style, color, size, spacing and location or, if not otherwise indicated, as selected by Architect from manufacturer's standard arrangements.

3.8 FIRE DEPARTMENT CONNECTION INSTALLATIONS:

A. Install automatic drip valves at the check valve on the fire department connection to the mains. Route drain to exterior.

B. Install mechanical sleeve seal at pipe penetration in outside walls.

3.9 ROOF MANIFOLD INSTALLATION:

A. Install automatic drip valves between control valve and roof manifold outlets as to drain entire length of pipe. Route drain to Janitor's sink.

B. Install mechanical sleeve seal at pipe penetration thru roof. Seal penetration water tight.

3.10 TEMPORARY CONSTRUCTION STANDPIPE SYSTEMS:

A. Temporary construction of standpipe risers shall be provided, along with hose, nozzles and valves as appropriate and as required by the Authority Having Jurisdiction. The risers shall continue up thru each floor as the floors are erected. Standpipes shall be supplied through a temporary Siamese inlet at grade located and sized as directed by the Authority Having Jurisdiction. Access to the temporary Siamese inlet connection shall be kept clear and accessible at all times. It shall be the responsibility of the Contractor to insure this temporary fire protection supply be available at all times. All valves shall be properly adjusted for the maximum pressure setting allowable.

B. The contractor shall be responsible for all design coordination and approval with the Authority Having Jurisdiction, construction and phasing of the temporary construction standpipe system.

3.11 FIRE HYDRANTS AND VALVE BOXES:

A. Fire hydrant shall be of sufficient length to allow the centerline of the nozzles to be 18 inches above finished grade, with 6inches flanged or mechanical joint inlet connection, 5-1/4inch valve opening, 4inch pumper nozzle, and two 2-1/2inch male hose nozzles. The hose nozzles threading shall be same as [Owner's existing fire hydrants] [municipal fire hydrants]. Operating nut shall be same as [Owner's existing fire hydrants] [municipal fire hydrants], with operating wrench, and shall be tested and listed by AWWA, UL and FM.

B. Valve box shall be adjustable sliding type of sufficient length to allow top to terminate flush with finishing grade, with round base and lid marked "Water" in integrally cast raised letters. Valve box shall be furnished with valve operating wrench of sufficient length to extend 3 feet above finished grade when engaged with valve.

C. Manufacturer and model number of fire hydrant shall have the approval of fire department having jurisdiction prior to being submitted to Architect/Engineer for review.

3.12 INSTALLATION OF BASIC IDENTIFICATION:

A. General: Install mechanical identification in accordance with Sections 23 05 00 and 23 05 53.

B. Install fire protection signs on piping in accordance with NFPA 13 and NFPA 14 requirements.

3.13 INSTALLATION OF METERS AND GAUGES:

A. Install meters and gauges in accordance with Section 23 05 19 "Meters and Gauges".

3.14 FIELD QUALITY CONTROL:

A. Flush, test and inspect sprinkler piping systems in accordance with NFPA 13, Standard for installation of sprinkler systems, Edition 1991 - Chapter 8.

B. The fire sprinkler system shall not be connected to underground piping until the fire service main is tested and approved (see 21.10.00).

C. The Fire Protection Contractor shall conduct and bear the costs of all necessary tests of the fire protection work, furnish all labor, power and equipment. All piping shall be tested with water as required, the tests witnessed by the authority having jurisdiction.

D. Dry and preaction systems shall be both hydrostatically and pneumatically tested. Pneumatic test shall be in accordance with NFPA-13.

E. The fire protection piping shall be tested under a hydrostatic pressure of not less than 200 psig, for a duration of not less than 2 hours.

F. Replace piping system components which do not pass the test procedures specified, and retest repaired portion of the system at Fire Protection Contractor's expense.

G. All piping tests (pneumatic and hydrostatic) shall be conducted prior to the application of any painting materials. This will prevent hidden leaks and/or repainting of repaired/altered piping.

3.15 SYSTEM CERTIFICATION:

A. The Contractor shall provide the Owner with written certification prior to final inspection, that all new equipment:

1. Has been visually inspected and functionally tested as required by the Specifications.

2. Is installed entirely in accordance with the manufacturer's recommendations within the limitations of the system's UL listings and NFPA criteria.

3. Is in proper working order.

3.16 FINAL INSPECTION AND TESTING:

A. The Contractor shall make arrangements with the Owner for final inspection and witnessing of the final acceptance tests. The Fire Protection Contractor, the Fire Alarm System Contractor and the Owner will conduct the final inspection and witness the final acceptance test.

B. All tests and inspections required by the referenced Codes and Standards, and the Owner shall be performed by the Contractor.

C. The inspecting committee as referenced above will visit the job site to inspect the work and witness the final acceptance tests when they have been advised by the Contractor that the work is completed and ready for test. If the work is not complete or the test is unsatisfactory, the Contractor shall be responsible for the Consultant's extra time and expenses for re- inspection and witnessing the re-testing of the work. Such extra fees shall be deducted from payments by the Owner to the Contractor.

D. After the system has been inspected and tested, a certificate, "Contractor's Material and Test Certificate Sprinkler System - Water Spray System," shall be provided by the contractor and shall be signed by him or his representative, the Owner's representative and by a representative of the fire department if appropriate. Sufficient copies shall be prepared to ensure the Engineer, Owner, all inspecting authorities and the contractor have a copy for their files. The Contractor shall prepare one (1) test report for each inspection performed whether successful or not.

E. The signing of the certificate by the Owner's representative shall in no way prejudice any claim against the contractor for faulty material, poor workmanship, or failure to comply with inspecting authority's requirements or local ordinances.

F. Contractor shall provide at least five (5) working days' notice for all tests.

G. All sprinkler supervisory initiating devices shall be functionally tested to verify proper operation.

H. All supervisory functions of each initiating device shall be functionally tested.

I. Receipt of all alarm and trouble signals, initiated during the course of the testing, shall be verified at the fire alarm control panel.

3.17 WORK BY OTHERS:

A. Wiring of all water flow switches and tamper switches on valves to central alarm panel are by Division 28.

3.18 OPERATION AND MAINTENANCE MANUAL:

A. The Contractor shall provide the Owner with a loose-leaf manual containing:

1. A detailed description of the systems.

2. A detailed description of routine maintenance required or recommended or which would be provided under a maintenance contract including a maintenance schedule and detailed maintenance instructions for each type of device installed.

3. One copy of NFPA-25.

4. Manufacturers' data sheets and installation manuals/instructions for all equipment installed.

5. A list of recommended spare parts.

6. Service directory, listing the specific equipment items and where parts can be obtained, with name, address and telephone number.

7. Full size sepias of the record drawings (stamped and signed per section 1.6).

8. Hydraulic calculations (stamped and signed per section 1.6).

9. Test certificates.

B. Refer to the LPS General Conditions of the Contract and other sections of Divisions 20 through 28 for additional requirements.

C. Within 15 days of the completion of the work, six (6) copies of the manual shall be submitted for approval.

3.19 RECORD DRAWINGS:

A. The Contractor shall provide and maintain on the site an up-to-date record set of approved shop drawing prints which shall be marked to show each and every change made to the sprinkler system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Owner without written instruction from the Owner in each case. This set of drawings shall be used only as a record set.

B. Upon completion of the work, the record set of prints shall be used to prepare complete, accurate final record drawings reflecting any and all changes and deviations made to the sprinkler system.

C. The Owner, at his option and at the Contractor's expense, may require revised hydraulic calculations depending on the extent and nature of field changes.

D. The Record Drawings and Hydraulic Calculations shall have the signed stamp of a professional engineer registered in the State of Colorado certifying the Record Drawings and the Hydraulic Calculations accurately represent the completed fire protection system.

E. Upon completion of the work, two sets of blueline record drawings shall be submitted to the Owner for review.

F. Upon correction of the blueline record drawings as needed, and after final approval, two (2) additional sets of blue line record drawings, one PDF version and one editable AutoCAD version shall be delivered to the Owner.

3.20 GUARANTEE PERIOD:

A. Guarantee: The Contractor shall guarantee all materials and workmanship for a period of one year beginning with the Date of Final Completion and Acceptance by the Owner. The Contractor shall be responsible during the design, installation, testing and guarantee periods for any damage caused by him (or his subcontractors) or by defects in his (or his subcontractors') work, materials, or equipment.

B. Emergency Service: During the installation and warranty period, the Contractor shall provide emergency repair service for the sprinkler system within four hours of a request by the Owner for such service. This service shall be provided on a 24 hour per day, seven days per week basis.

3.21 TRAINING:

A. The Contractor shall conduct two (2) training sessions of four (4) hours each to familiarize the building personnel with the features, operation and maintenance of the sprinkler systems. Training sessions shall be scheduled by the Owner at a time mutually agreeable to the Contractor and the Owner.

3.22 WATER DAMAGE:

A. The Fire Protection Contractor shall be responsible for any damage to the work of others, to building and property/ materials of others caused by leaks in automatic sprinkler equipment, unplugged or disconnected pipes or fittings, and shall pay for necessary replacement or repair of work or items so damaged during the installation, testing or guarantee periods of the automatic sprinkler work.

**END OF SECTION 21 10 00**

# 21 30 00 Fire Pumps

PART 1 - GENERAL

1.1 SUMMARY:

A. This Section includes fire pumps.

B. Refer to Division 3 for concrete work for formwork, reinforcement, and concrete for equipment pads.

C. Refer to Division 7 for flashing and sheet metal for roof and wall penetrations

D. Refer to Divisions 20 through 25 for mechanical/electrical requirements, mechanical identification, fire protection system, piping and fuel systems.

E. Refer to Divisions 26 and 28 for electrical connection for equipment, power-supply wiring, field-installed electrical devices, and fire alarm systems.

1.2 DEFINITIONS:

A. Fire Pump: Pump intended to supply water, at rated capacity and at total rated head, required for fire protection service.

B. Fire pump unit is defined as an assembled unit consisting of fire pump, driver, controller, and accessories.

C. Horizontal fire pump category includes axially-split-case (both horizontal and vertical mounting) and radially-split-case (both end suction and vertical in line) fire pump types.

D. Pressure Maintenance Pump: Pump intended to maintain water pressure in system.

E. Pressure maintenance pump unit is defined as an assembled unit consisting of pressure maintenance pump, driver, controller, and accessories.

1.3 SYSTEM PERFORMANCE REQUIREMENTS:

A. Provide fire pump systems consisting of fire pump units, pressure maintenance pump units, accessories, and piping, complying with performance requirements determined by fire protection design-build contractor, and compatible with building fire protection systems.

1.4 SUBMITTALS:

A. General: Submit the following in accordance with the LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

B. Product data for each fire pump unit and each pressure pump unit, including clearly stated rated capacities of each selected model, performance curve with each selection point indicated, driver, pump controller, furnished specialties, and accessories; plus weights (shipping and installed).

C. Installation and start-up instructions for each fire pump unit and each pressure maintenance pump unit.

D. Product certificates signed by manufacturers of fire pumps, certifying that their products comply with specified requirements.

E. Test curves of fire pump manufacturer's factory shop tests for each fire pump and certificates signed by manufacturer verifying that the test results comply with specified requirements.

F. Welding procedures specifications for each welding process, welding procedures qualifications test records, and welders' qualification test records complying with requirements specified in "Quality Assurance" below.

G. Shop drawings showing the layout and connections for each fire pump unit and each pressure maintenance pump unit, including pump, pump driver, pump controller, related accessories, and piping. Include setting drawings with templates, and directions for installation of foundation bolts, anchor bolts, and other anchorages.

H. Wiring diagrams detailing field-installed wiring for power, signal, and control systems.

I. Field acceptance test data showing proper performance in accordance with provisions specified.

J. Maintenance Data: Submit maintenance data for each type of fire pump unit and pressure maintenance pump unit for inclusion in Operating and Maintenance Manual specified in the LPS General Conditions of the Contract and Section 21 10 00.

1.5 QUALITY ASSURANCE:

A. Manufacturer Qualifications: Firms whose fire pumps, pressure maintenance pumps, drivers, controllers, and major accessories are listed by product name and manufacturer in UL "Fire Protection Equipment Directory" and FM "Approval Guide" and comply with other requirements indicated. Pressure maintenance pumps are exempt from UL and FM requirements. Pressure maintenance pump controllers are exempt from FM requirement. Flow measuring systems are exempt from UL requirement. Those products which have been in satisfactory use in similar service for not less than 5 years.

B. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.

C. Comply with local fire department/marshal standards pertaining to material, hose threads, and installation.

D. Comply with the requirements of NFPA 20 "Centrifugal Fire Pumps" for fire pumps, drivers, controllers, accessories, materials, and installation.

E. Comply with the requirements of NFPA 70 "National Electrical Code" for electrical materials and installation.

F. Comply with the requirements of FM "Approval Guide" as applicable to fire pumps, drivers, controllers, and accessories, and provide system capable of FM acceptance.

G. Regulatory Requirements: Comply with the provisions of the following:

1. ASME B31.9 "Building Services Piping" for materials, products, and installation.

2. ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators according to Section 20 10 00, 1.2D.

H. Manufacturer's Factory Tests: Perform factory test of each fire pump. Copy to be submitted to Engineer prior to shipment.

1.6 DELIVERY, STORAGE, AND HANDLING:

A. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles.

B. Store fire pumps, pressure maintenance pumps, drivers, controllers, and accessories in a clean dry place.

C. Retain shipping flange protective covers and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. For extended storage greater than 5 days, dry internal parts with hot air or a vacuum-producing device to avoid rusting internal parts. Upon drying, coat internal parts with a protective liquid, such as light oil. Dismantle bearings and couplings, dry and coat them with an acid-free heavy oil, and then tag and store in a dry location.

F. Comply with Manufacturer's rigging instructions for handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Axially-Split-Case Fire Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump
   c. Fairbanks Morse Pump Div.; Colt Industries.
   d. Patterson
   e. Peerless Pump; A Sterling Co.

2. End Suction, Radially-Split-Case Fire Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump

3. In-Line, Radially-Split-Case Fire Pumps:
   a. Aurora Fire Pump
   b. Peerless Pump; A Sterling Co.

4. Vertical Turbine Fire Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump
   c. Fairbanks Morse Pump Div.; Colt Industries.
   d. Peerless Pump; A Sterling Co.
   e. Goulds Pumps, Inc.

5. Multi-Stage, Pressure Maintenance Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump
   c. Peerless Pump; A Sterling Co.

6. Regenerative Turbine, Pressure Maintenance Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump
   c. Fairbanks Morse Pump Div.; Colt Industries.

7. Vertical Turbine, Pressure Maintenance Pumps:
   a. Allis-Chalmers Corp.; Industrial Pump Div.
   b. Aurora Fire Pump
   c. Fairbanks Morse Pump Div.; Colt Industries.
   d. Peerless Pump; A Sterling Co.

8. Electric Motor Drivers: Electric motor driver manufacturers are option of fire pump manufacturers. Electric motor curves are to be submitted prior to bid date.
   a. Aurora Fire Pump
   b. Diesel Engine Drivers:
   c. Caterpillar, Inc.
   d. Clarke GM Diesel, Inc.
   e. Cummins Engine Co., Inc.

9. Diesel Engine Driver Gear Drives: Right-angle gear drive manufacturers are option of fire pump manufacturers.

10. Fire Pump Controllers, Alarm Panels, and Pressure Maintenance Pump Controllers:
    a. Firetrol, Inc.
    b. Metron, Inc.

11. Flow Measuring Systems:
    a. Barco Div.; Marison Industries.
    b. Dieterich Standard; A Dover Industries Co.
    c. Gerand Engineering Co.

2.2 FIRE PUMP SYSTEMS, GENERAL:

A. Fire Pump Systems: Provide fire pump units and pressure maintenance pump units, having specified compatible components and accessories.

B. Horizontal fire pumps, except in-line type, and drivers shall be factory assembled, mounted on same base, and connected with a flexible coupling having a guard.

C. Vertical turbine fire pumps and electric motor drivers shall be factory assembled.

2.3 FIRE PUMPS, GENERAL: V

A. Fire Pumps: UL 448, base-mounted, factory-assembled, and factory-tested, of types, capacities, and characteristics indicated.

B. Fire Pumps: Base-mounted, factory-assembled, and factory-tested, of types, capacities, and characteristics indicated.

C. Preparation for Shipping: After assembly and testing, clean flanges and exposed machined metal surfaces and treat with an anticorrosion compound. Protect flanges, pipe openings, and nozzles.

D. Nameplates: Provide nameplates, complete with capacities, characteristics, and other pertinent data.

E. Factory Finish: Red, enamel paint applied to assembled, tested units prior to shipping.

2.4 AXIALLY-SPLIT-CASE FIRE PUMPS:

A. Characteristics: Fire pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shutoff head shall not exceed 120 percent of total rated head.

B. General Description: Base-mounted, centrifugal, separately coupled, bronze-fitted, axially-split-case design, specifically labeled for fire service.

1. Type: Horizontally mounted, single stage - double suction.
2. Type: Horizontally mounted, multistage - single suction.
3. Type: Vertically mounted, single stage - double suction.

C. Casing Construction: Axially-split-case centrifugal design; cast-iron pump casing with suction and discharge flanges machined to ANSI B16.1 dimensions, and 125-psi pressure rating, except where 250-psi rated flanges are indicated.

D. Impeller Construction: Statically and dynamically balanced, of construction to match type fire pump, fabricated from cast bronze, keyed to shaft.

E. Wear Rings: Replaceable, bronze.

F. Pump Shaft and Sleeve: Steel shaft, with bronze sleeve.

G. Pump Shaft Bearings: Grease-lubricated ball bearings contained in a cast-iron housing.

H. Seals: Stuffing box consisting of a minimum of 4 rings of graphite-impregnated braided yarn with a bronze lantern ring between center 2 graphite rings, and a bronze packing gland.

I. Pump Couplings: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

J. Motor: Flexible-coupled to pump.

K. Baseplate: Steel construction with grout holes, I beam will not be allowed.

2.5 RADIALLY-SPLIT-CASE FIRE PUMPS:

A. Characteristics: Fire pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shutoff head shall not exceed 140 percent of total rated head.

B. End-Suction-Type Fire Pump General Description: Base-mounted, centrifugal, separately coupled, end-suction, single-stage, bronze-fitted, radially-split-case design, specifically labeled for fire service.

1. Pump Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment; complete with metal coupling guard.

2. Motor: Flexible-coupled to pump.

C. In-Line-Type Fire Pump General Description: Centrifugal, close-coupled, single-stage, vertical in-line, bronze-fitted, radially-split-case design, specifically labeled for fire service.

1. Motor: Direct-mounted to pump casing.

D. Casing Construction: Radially-split-case centrifugal design; cast-iron pump casing with suction and discharge flanges machined to ANSI B16.1 dimensions, and 125-psi pressure rating, except where 250-psi rated flanges are indicated.

E. Impeller Construction: Statically and dynamically balanced, closed, overhung, single-suction, cast bronze, and keyed to shaft.

F. Wear Rings: Removable, bronze.

G. Pump Shaft and Sleeve: Ground and polished steel shaft, with bronze sleeve.

H. Seals: Stuffing box having a minimum of 4 rings of graphite-impregnated braided yarn with a bronze lantern ring between center 2 graphite rings and a bronze packing gland.

I. Base or Pedestal: Steel or Cast Iron

2.6 VERTICAL TURBINE FIRE PUMPS:

A. Characteristics: Fire pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. The total shutoff head shall not exceed 140 percent of total rated head.

B. General Description: Vertical shaft turbine type, centrifugal design, having impellers discharging into bowls and a vertical pump column, specifically labeled for fire service.

C. Pump Head Construction: Cast iron, with discharge flange machined to ANSI B16.1 dimensions, and 125-psi pressure rating, except where 250-psi rated discharge flange is indicated.

D. Line Shaft: Stainless steel or steel with corrosion-resistant shaft sleeves.

E. Pump Line Shaft Bearings: Rubber sleeve water lubricated.

F. Line Shaft: Steel.

G. Pump Line Shaft Bearings: Corrosion-resistant oil lubricated.

H. Impeller Shaft: Monel metal or stainless steel.

I. Pump Bowl Assemblies: Cast-iron with closed type bronze impellers.

J. Pump Column: Of length indicated.

K. Suction Cans must be UL/FM approved.

L. Suction Strainer: Cast or fabricated nonferrous corrosion- resistant metal suction strainer having free area not less than 4 times suction inlet cross-sectional area, with the openings that will not permit passage of a 5/16-inch sphere for pump rating of 500 gpm or less and a 1/2-inch sphere for pump rating more than 500 gpm.

2.7 ELECTRIC MOTORS:

A. Fire Pump Electric Motor Drivers: NEMA MG 1, open drip-proof, squirrel cage, induction motor, complying with NFPA 20 and NFPA 70, and wiring compatible with type controller used.

B. Fire Pump Electric Motor Drivers: Vertical hollow shaft, open drip-proof, squirrel cage, induction motor, complying with NFPA 20 and NFPA 70, and wiring compatible with type controller used. Construction of motor such that total hydraulic and static thrust of pump rotating assembly can be carried by motor thrust bearings. Mount motor directly on pump discharge head assembly for correct shaft alignment. Equip motor with top drive coupling and nut for axial adjustment of pump impellers, and non-reverse ratchet to prevent pump backspin.

C. Fire Pump Motor Nameplates: Provide nameplates, complete with motor horsepower, characteristics, and other pertinent data.

D. Fire Pump Motor Factory Finish: Red, enamel paint, same as for fire pump, applied to assembled, tested units prior to shipping.

E. Pressure Maintenance Pump Electric Motors: NEMA MG 1, open drip-proof, squirrel cage, induction motor, complying with NFPA 20 fire pump motor requirements and NFPA 70, and wiring compatible with controller.

F. Pressure Maintenance Pump Motor Factory Finish: Enamel paint, same as for pressure maintenance pump, applied to assembled unit.

2.8 DIESEL ENGINES:

A. Fire Pump Diesel Engine Driver: UL 1247, horizontal shaft, open-type diesel engine, of scheduled capacity. Provide the following accessories for automatic operation:

B. Fire Pump Diesel Engine Driver: UL 1247, horizontal shaft open-type diesel engine, of scheduled capacity, for operation with right-angle gear drive. Provide the following accessories, compatible with and of capacity to match diesel driver, for automatic operation:

1. Emergency manual operator, factory-wired, for standby engine starting and operation in case of main controller or wiring malfunction.

2. Engine cooling system consisting of water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings; factory-installed.

3. Flexible exhaust connector.

4. Residential exhaust silencer (85 dBA).

5. Commercial exhaust silencer.

6. Engine jacket water heater, factory-installed, electric elements.

7. Dual batteries, lead-acid-storage type, providing 100 percent standby reserve capacity.

8. Fuel system, in compliance with NFPA 20.

9. Fuel storage tank, of size indicated, with floor legs and direct-reading level gauge.

10. Exhaust System, ASTM A 53, Type E or Type S, Schedule 40, black steel pipe, ANSI B16.9 weld-type pipe fittings, ANSI B16.5 steel flanges, ANSI B16.21 nonmetallic gaskets, and fabricated double wall steel pipe ventilated thimble.

C. Gear Drive: Vertical hollow shaft right-angle gear drive unit. Direct connect drive to pump shaft and equip with non-reverse ratchet. Connect drive to engine with flex shaft with enclosing guard. Provide drive with provision for adjusting pump impeller lateral setting for proper pump operation and performance.

D. Nameplates: Provide nameplates, complete with engine horsepower, characteristics, and other pertinent data.

E. Factory Finish: Red, enamel paint same as for fire pump, applied to assembled, tested unit and to ferrous metal accessories, except where other finish is specified, prior to shipping.

2.9 FIRE PUMP CONTROLLERS AND ALARM PANELS, GENERAL:

A. Fire Pump Controllers and Alarm Panels: Combined automatic and non-automatic operation, UL listed and FM approved, factory-assembled and wired, and factory-tested, of types, capacities, electrical characteristics, and with features indicated.

1. Standard: UL 508.

B. Enclosure: NEMA ICS 6, Type 2, drip-proof, indoor, except where special-purpose enclosure is indicated.

C. Provide controls, devices, alarms, functions, and operations listed in NFPA 20, as required for the type driver and controller used, and the specific items listed for each type controller.

D. Nameplates: Provide nameplate complete with capacity, electrical characteristics, approvals and listings, and other pertinent data, on enclosure door.

E. Provide mounting for enclosures as indicated:

1. Full-Service Fire Pump Controller Mounting: Wall or floor stand type, as indicated, for field electrical connections.

2. Full-Service Fire Pump Controller Mounting: Wall type, for field electrical connections.

3. Full-Service Fire Pump Controller Mounting: Floor stand type, for field electrical connections.

4. Full-Service Fire Pump Controller Mounting: Unit mounted on pump base and factory-wired.

5. Limited-Service Fire Pump Controller Mounting: Wall or floor stand type, as indicated, for field electrical connections.

6. Limited-Service Fire Pump Controller Mounting: Wall type, for field electrical connections.

7. Limited-Service Fire Pump Controller Mounting: Floor stand type, for field electrical connections.

8. Alarm Panel Mounting: Wall type.

9. Factory Finish: Red, enamel paint applied to assembled, tested units prior to shipping.

F. Controller Sensing Pipes: Provide nonferrous metal sensing piping, 1/2-inch size, with 1/2-inch globe valves for testing mechanism of controller, from system to pump controller, as indicated.

Provide bronze check valve with 3/32-inch orifice in clapper or ground-face union with noncorrosive diaphragm having 3/32-inch orifice.

1. Fabricate pipe and fittings in accordance with NFPA 20.

2.10 FULL-SERVICE, ELECTRIC-MOTOR-DRIVE FIRE PUMP CONTROLLERS:

A. Motor Controllers: Controller specifically listed for electric motor drive fire pump service and service entrance.

EDIT NOTE: Coordinate and select starter type with Electrical Engineer. Also, coordinate terminal lug sizes with Electrical Engineer.

1. Type: Across the line (up to 75 HP).
2. Type: Primary resistance (up to 100 HP).
3. Type: Part winding (up to 100 HP).
4. Type: Wye-delta (closed transition) (up to 100 HP).
5. Type: Wye-delta (open transition) (up to 100 HP).
6. Type: Autotransformer

B. Rate controller for scheduled horsepower. Provide controller with short circuit withstand rating at least equal to short circuit current available at controller location, taking into account cable size and distance from substation or supply transformers.

EDIT NOTE: ATC only where required for dual feed or emergency power.

C. Automatic Transfer Switch: Enclosure complying with requirements for and attached to fire pump controller above, containing an automatic transfer switch having rating at least equal to the fire pump driver motor horsepower; or when motor is rated in amperes, shall have an ampere rating not less than 115 percent of the motor full-load current and also shall be suitable for switching the motor locked rotor current. Provided by [coordinate with electrical].

1. Standard: UL 1008.

D. Voltage Surge Arrestor: Provide voltage surge arrestors complying with ANSI C62.1 or C62.11 installed from each line terminal of the isolating switch to ground. These devices shall be rated to suppress voltage surges above rated line voltage.

E. Provide controller capable of performing or containing the following features:

1. Isolating means and circuit breaker.
2. "Power Available" and "Phase Reversal" pilot lamps.
3. Ammeter with current transducers.
4. Three separate dry contacts indicating motor running condition, loss of line power (including low voltage or loss of any one phase), and line power phase reversal.
5. Automatic and manual operation, and minimum run time relay to prevent short cycling.
6. Remote start.
7. Water pressure actuated switch having independent high and low calibrated adjustments responsive to water pressure in fire protection system.
8. Manual and automatic shutdown.
9. Emergency start lever bypassing all control circuits.

2.11 LIMITED-SERVICE, ELECTRIC-MOTOR-DRIVE FIRE PUMP CONTROLLERS:

A. Motor Controllers: Limited-service controller for electric motor drive fire pump service, and service entrance.

EDIT NOTE: Coordinate starter type and terminal lug sizes with Electrical Engineer.

1. Type: Across the line.

B. Rate controller for scheduled horsepower. Provide controller with short circuit withstand rating at least equal to short circuit current available at controller location, taking into account cable size and distance from substation or supply transformers.

2.12 DIESEL ENGINE DRIVE FIRE PUMP CONTROLLERS:

A. Engine Controllers: Controller specifically listed for diesel engine drive fire pump service, capable of performing or containing the following features:

1. Built-in dual battery charger.
2. Time clock for weekly automatic test.
3. System pressure recorder, electric alternating current driven with spring backup.
4. Timing relay for automatic stop.
5. Power failure start, with time delay to prevent start at momentary loss of power.
6. Low-fuel-level alarm.
7. Alarm contacts for remote alarm of "Engine Run," "Switch Off," and "Engine Failure."
8. Pump room alarms shall be both audible and visible signals.

2.13 ALARM PANELS:

A. Alarm Panel: NEMA ICS 6, Type 1 remote wall-mounting-type panel with audible and visible alarms matching type controller used. Provide following features and manufacturer's standard features:

1. Electric Motor Drive Fire Pump Controller Alarm Panels:
   a. Motor operating condition.
   b. Loss of line power.
   c. Phase reversal.
   d. Low water alarm.

2. Diesel Engine Drive Fire Pump Controller Alarm Panels:
   a. Engine running.
   b. Main switch off or in manual position.
   c. Engine trouble.
   d. Low water alarm.
   e. Low fuel.

2.14 HORIZONTAL FIRE PUMP ACCESSORY FITTINGS:

A. Provide the following accessory fittings, matching fire pump suction and discharge ratings, as required for fire pump capacity rating:

1. Automatic air release valve.

2. Casing relief valve.

3. Suction and discharge pressure gauges.

4. Eccentric tapered reducer at suction inlet.

5. Concentric tapered reducer (increaser) at discharge outlet.

6. Hose valve test header manifold and round brass identification escutcheon plate, for wall mounting, manufacturer's standard finish, with lettering equivalent to "PUMP TEST CONN."

7. Hose valves with caps and chains, NFPA 1963 hose thread conforming to local fire department standards, bronze finish.

8. Ductile iron or brass body, hose valve test header manifold having nozzle outlets arranged in a single line, for horizontal flush wall mounting, polished chrome-plated rectangular brass escutcheon plate with lettering equivalent to "PUMP TEST CONNECTION."

9. Hose valves with caps and chains, NFPA 1963 hose threads conforming to local fire department standards, bronze with polished chrome finish.

10. Ball drip valve.

11. Main relief valve, UL 1478.

12. Closed discharge cone.

13. Open discharge cone.

14. Factory Finish: Red, enamel paint except where brass or other finish is specified.

2.15 VERTICAL TURBINE FIRE PUMP ACCESSORY FITTINGS:

A. Provide the following accessory fittings, matching fire pump discharge rating, as required for fire pump capacity rating:

1. Automatic air release valve.

2. Casing relief valve.

3. Discharge pressure gauge.

4. Concentric tapered reducer (increaser) at discharge outlet.

5. Hose valve test header manifold and round brass identification escutcheon plate, for wall mounting, manufacturer's standard finish, with lettering equivalent to "PUMP TEST CONN."

6. Hose valves with caps and chains, NFPA 1963 hose threads conforming to local fire department standards, bronze finish.

7. Ductile iron or brass body, hose valve test header manifold having nozzle outlets arranged in a single line, for horizontal flush wall mounting, polished chrome-plated rectangular brass escutcheon plate with lettering equivalent to "PUMP TEST CONNECTION."

8. Hose valves with caps and chains, NFPA 1963 hose threads conforming to local fire department standards, bronze with polished chrome finish.

9. Ball drip valve.

10. Main relief valve, UL 1478.

11. Closed discharge cone.

12. Open discharge cone.

13. Water level detecting device, ASTM B 88 Type L copper water tube, ANSI B16.22 wrought-copper, solder-joint fittings, ASTM B 32 Alloy Sb5 solder; with pressure gauge and connection fitting for attaching a hand-operated air pump. Piping arrangement and length shall be as detailed in NFPA 20 Appendix A.

B. Factory Finish: Red, enamel paint except where brass or other finish is specified.

2.16 PRESSURE MAINTENANCE PUMPS:

A. Pressure Maintenance Pumps, General: Base-mounted, factory- assembled, and factory-tested, of pump types, capacities, and electrical characteristics indicated. Close coupled pressure maintenance pumps are exempt from base-mounted requirement.

B. Characteristics: Pressure maintenance pumps shall furnish not less than rated capacity at not less than total rated head indicated.

C. Construction: Cast-iron pump casing with suction and discharge connections of size indicated, threaded, or flanged and machined to ANSI B16.1 dimensions, and 125-psi minimum pressure rating, except where 250-psi rated flanges are indicated.

1. Impeller: Bronze or stainless steel.
2. Shaft: Stainless steel.
3. Seals: Mechanical.

D. Nameplates: Provide nameplate complete with capacity, electrical characteristics, and other pertinent data.

E. Factory Finish: Manufacturer's standard color enamel paint applied to assembled, tested units prior to shipping.

F. Multi-Stage Pressure Maintenance Pumps:

1. Construction: Multi-stage, centrifugal, vertical construction, base mounting.

G. Regenerative Turbine Pressure Maintenance Pumps:

1. Construction: Regenerative turbine, close coupled construction, for pad mounting.

H. Vertical Turbine Pressure Maintenance Pumps:

1. Construction: Vertical turbine, base mounting.
2. Pump Head: Cast iron.
3. Line Shaft: Stainless steel or steel with corrosion-resistant shaft sleeves.
4. Pump Line Shaft Bearings: Rubber sleeve water lubricated.
5. Line Shaft: Steel.
6. Pump Line Shaft Bearings: Corrosion-resistant oil lubricated.
7. Impeller Shaft: Monel metal or stainless steel.
8. Pump Bowl Assemblies: Cast-iron with closed-type bronze impellers.
9. Pump Column: Of length indicated.

10. Suction Strainer: Cast or fabricated nonferrous corrosion- resistant metal suction strainer having free area not less than 4 times suction inlet cross-sectional area; with the openings that will not permit passage of a 5/16 inch sphere.

2.17 PRESSURE MAINTENANCE PUMP CONTROLLERS:

A. Pressure Maintenance Pump Controllers: Combined automatic and non-automatic operation, UL listed, factory-assembled and wired, and factory-tested, of types, capacities, electrical characteristics, and with features indicated, for electric motor drive pressure maintenance pump service.

1. Type: Across the line.
2. Standard: UL 508.

B. Enclosure: NEMA ICS 6, Type 2, wall mounted, for field electrical wiring.

C. Provide controls, devices, alarms, functions, and operations listed in NFPA 20, and the specific items listed.

D. Rate controller for scheduled horsepower and provide the following items:

1. Fusible disconnect switch.
2. Pressure switch.
3. "HAND-OFF-AUTO" selector switch.
4. Pilot light.
5. Running period timer.

E. Nameplates: Provide nameplate complete with capacity, electrical characteristics, approvals and listings, and other pertinent data, on enclosure door.

F. Mounting: Wall type for field electrical connections.

G. Factory Finish: Manufacturer's standard color enamel paint applied to assembled, tested units prior to shipping.

H. Controller Sensing Pipes: Provide nonferrous metal sensing piping, ½ inch size, with ½ inch globe valves for testing mechanism of controller, from system to pump controller, as indicated. Provide bronze check valve with 3/32 inch orifice in clapper or ground-face union with noncorrosive diaphragm having 3/32 inch orifice.

1. Fabricate pipe and fittings in accordance with NFPA 20.

2.18 PRESSURE MAINTENANCE PUMP ACCESSORIES:

A. Provide following accessory fittings, matching pressure maintenance pump suction and discharge ratings, as required for pump capacity rating:

1. Casing relief valve.
2. Suction and discharge pressure gauges.

2.19 FLOW MEASURING SYSTEMS:

A. General: Fire pump flow measuring systems shall be FM approved, indicate flow in gpm to not less than 175 percent of fire pump rated capacity, and consist of a sensing element of size to match pipe, tubing, flow meter, and fittings.

B. Pressure Rating: 175 psi minimum.

C. Provide flow measuring device manufactured by Meriam Model FM-D15 6 inch dial flow meter; Barco or equal.

D. Provide flow measuring systems complete with operating instructions.

2.20 SOURCE QUALITY CONTROL:

A. Factory Tests: Hydrostatically test and test run each pump prior to shipment. Test at 150 percent of shut-off head plus suction head, but not less than 250 psig. Produce certified test curves showing head capacity and brake-horsepower of each pump.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas, equipment foundations, and conditions with Installer present, for compliance with requirements for installation and other conditions affecting performance of fire pumps. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine fire protection piping systems to verify actual locations of piping connections prior to installation.

3.2 INSTALLATION OF FIRE PUMPS:

A. General: Comply with the manufacturer's written installation and alignment instructions and with NFPA 20 and FM standards.

B. Install pumps in locations indicated and arrange to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that the weight of the piping system does not rest on pumps.

D. Set base-mounted pumps on concrete foundations. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.

2. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.

E. Provide piping accessories, hangers, supports and anchors, valves, meters and gauges, and equipment supports as indicated for complete installation.

F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable.

3.3 ALIGNMENT:

A. Align pump and driver shafts after complete unit has been leveled on foundation and after grout has set and foundation bolts have been tightened.

B. After alignment is correct, tighten the foundation bolts evenly but not too firmly. Fill the base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has hardened, fully tighten foundation bolts. Check alignment and take corrective measures required.

C. Make piping connections, check alignment, and take corrective measures required.

1. Adjust alignment of pump and driver shafts for angular and parallel alignment by one of the two methods specified in the Hydraulic Institute "Centrifugal Pumps - Instructions for Installation, Operation and Maintenance."

2. Alignment tolerances shall meet manufacturer's recommendations.

3.4 CONNECTIONS:

A. General: Install valves of types and at locations indicated, that are same size as the piping connecting the fire pump, bypass, test header, and other piping systems.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of fire pump nozzles.

C. Install pressure gauges on the suction and discharge of each pump at the integral pressure gauge tappings provided.

D. Install cooling system piping connection for water supply to heat exchanger, and piping and connection for drain from heat exchanger to point of disposition.

E. Install exhaust system piping from diesel engine driver to point of termination outside the structure. Install pipe and fittings with welded joints, and components having flanged connections with gasketed joints.

F. Install flow meters and sensing elements where indicated. Install connections, tubing, and fittings between flow sensing elements and meters as prescribed by manufacturer's installation instructions.

G. Electrical wiring and connections are specified in Divisions 26 and 28 sections.

3.5 FIELD QUALITY CONTROL:

A. Manufacturer's Field Service: Provide the services of a factory-authorized service representative to supervise field assembly of components, installation of fire pump units and pressure maintenance pump units, including piping and electrical connections, field acceptance tests, and to report test results in writing.

B. Check suction lines connections for tightness to avoid drawing air into the pump.

C. Perform field acceptance tests of each fire pump unit (fire pump, driver, and controller) and system piping, when installation of fire pump units is complete. Comply with operating instructions and procedures of NFPA 20 to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be satisfactorily corrected or that does not

perform as specified and as indicated, then retest to demonstrate compliance. Verify that each fire pump unit performs as specified and as indicated.

3.6 COMMISSIONING:

A. Start-Up Services, General: Provide the services of a factory-authorized service representative to provide start-up service and to demonstrate and train Owner's maintenance personnel as specified below.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.

2. Train Owner's maintenance personnel on procedures and schedules related to start-up and shutdown, troubleshooting, servicing, and preventative maintenance.

3. Review data in Operating and Maintenance Manuals. Refer to the LPS General Conditions of the Contract "Project Closeout."

4. Schedule training with at least 7 days' advance notice.

5. Provide fire hoses in number, size, and of length as required to reach a storm drain or other acceptable location for the disposal of fire pump test water. These fire hoses are for use during field acceptance tests only and are not to become property of the Owner.

B. Final Checks Before Start-Up: Perform the following preventative maintenance operations and checks before start-up:

1. Lubricate oil-lubricated bearings.

2. Remove grease-lubricated bearing covers and flush the bearings with kerosene and thoroughly clean. Fill with new lubricant in accordance with the manufacturer's recommendations.

3. Disconnect coupling and check electric motor for proper rotation. Rotation shall match direction of rotation marked on pump casing.

4. Check that pump is free to rotate by hand. If the pump is bound or even drags slightly, do not operate the pump until the cause of the trouble is determined and corrected.

5. Install coolant in cooling system. Fill closed loop cooling system with potable water and add a rust inhibitor.

6. Install coolant in cooling system. Fill closed loop cooling system with a solution of 50 percent potable water and 50 percent ethylene glycol permanent antifreeze. Add rust inhibitor, if not included in antifreeze.

C. Starting procedure for pumps:

1. Prime the pump, opening the suction valve, closing the drains, and prepare the pump for operation.

2. Open the sealing liquid supply valve if the pump is so fitted.

3. Start motor.

4. Open the discharge valve slowly.

5. Observe the leakage from the stuffing boxes and adjust the sealing liquid valve for proper flow to ensure the lubrication of the packing. Do not tighten the gland immediately, but let the packing run in before reducing the leakage through the stuffing boxes.

6. Check the general mechanical operation of the pump and motor.

**END OF SECTION 21 30 00**

## END OF DIVISION 21

# DIVISION 22 PLUMBING

## 22 05 00 Common Work Results for Plumbing

- In the absence of other information, standards of the following organizations apply:
  - Americans With Disabilities Act (ADA)
  - American Gas Association (AGA)
  - American National Standards Institute (ANSI)
  - American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)
  - American Society of Mechanical Engineers (ASME)
  - American Water Works Association (AWWA)
  - International Association of Plumbing and Mechanical Officials (IAPMO)
  - International Building Code (IBC)
  - International Fuel Gas Code (IFGC)
  - International Mechanical Code (IMC)
  - International Plumbing Code (IPC)
  - National Electrical Code (NEC)
  - National Electrical Manufacturers Association (NEMA)
  - Plumbing and Drainage Institute (PDI)
  - Underwriters Laboratories (UL)
  - Local water and sewer districts
- Install plumbing control devices in "Readily Accessible" locations as defined by Chapter 1, Article 100, of the applicable National Electrical Code.
  - PROHIBITTED: Operating plumbing equipment, such as pumps, in ceiling spaces without written approval of Littleton Public Schools (LPS) Operations, Maintenance and Construction Department (OMC) and LPS Project Manager (PM).
- When reusing or connecting to existing piping, confirm and coordinate with LPS OMC and LPS PM requirements to clean and test the existing system.
- Connections to existing potable water supply piping shall be made with new isolation valves.
- REQUIRED: Isolation valves at every branch line and other strategic areas throughout facility to isolate
  - Bathrooms and toilet groups
  - Kitchens
  - Classrooms

  - Other areas with large water demands.
- Isolation valves at every branch line feeding bathrooms and class rooms
- Piping located in crawl spaces or horizontal pipe and utility chases
  - Bottom of piping shall be at least 4-feet from grade or slab below to allow for adequate maintenance access.
- Provide adequate facilities for cleaning of sewer and waste lines.
- Provide stub-out of utilities for temporary facilities required by LPS design programs.
- Consider future addition(s) when sizing utilities.
- Refer to Section 11 40 00 Food Service Equipment for Kitchen requirements.
- Potable domestic water systems shall be lead-free.
  - Provide documentation/certification that components are lead-free.
- All material listed to be delivered to LPS at Final Acceptance shall be documented in a single list to be signed as being accepted by the LPS OMC and forwarded to LPS PM.
- Piping
  - Service and supply
    - RESTRICTED: Copper only
      - Substitution requires pre-approval by the LPS OMC and LPS PM
    - Copper service and supply Type L
    - Underground copper lines to be Type K
  - Drain, waste, vent
    - PVC waste and vent is preferred over cast where allowed by code.
  - Fittings
    - PROHIBITED: Dielectric unions
    - RESTRICTED: Fittings for copper pipe only
    - Approved fittings/methods
      - ProPress
        - Maximum size 2 ½" or less
      - Soldered Copper
      - Victaulic (groove-lock)
    - Any other than these approved methods must be reviewed and approved for each specific case by LPS OMC and LPS PM prior to Construction Documents.
- Submittals
  - Closeout

- MANDITORY: PDF copy of water treatment chlorination report

**26 05 29 Hangers and Supports for Plumbing Piping and Equipment**

- Roof top gas pipe support
  - Shall be steel and be properly supported by Unistrut-type roof stands
  - Hot dipped galvanized
  - Size as required for gas pipe on roof
  - Spaced a minimum of 10' o.c. and at all corners.
  - Install over an extra layer of specified walkway pad.
  - Approved manufacturer(s)
    - Miro Industries
      - Model Numbers 4-RAH or 6-RAH HG
    - Approved equivalent

## 22 10 00 Plumbing Piping

### 22 11 00 Facility Water Distribution

- This Section specifies the water distribution piping system, including potable cold, hot, and recirculated hot water piping, fittings, and specialties within the building to a point 5 feet outside the building.
- Products installed but not furnished under this Section include water meters which will be provided by the utility company, to the site, ready for installation.
  - Utility companies:
    - Denver Water, 1600 West 12th Avenue, Denver CO 80204
    - Willow Water District, 6930 South Holly Circle, Englewood CO 80112
      - Provider for Lenski ES (only)
- Submittals
  - Data
    - For each piping specialty and valve specified.
    - Certification of Compliance with ASME and UL fabrication requirements.
    - Manufacturer and product data for lead free solder with material breakdown.
  - O & M manual.
    - Maintenance data for each piping specialty and valve specified
  - Closeout
    - Submittals listed above updated to record status
    - Test reports

- Copies of certification reports for backflow prevention devices that were forwarded to appropriate jurisdiction
- PDF copy of water treatment chlorination report

▪ Maintenance Stock

- One valve key for each key operated wall hydrant, hose bibb, or faucet installed.

- Hose Bibbs and Faucets
  - o Unfinished Areas and Equipment Room
    - ▪ Rough bronze body
    - ▪ Renewable composition disc
    - ▪ Wheel handle
    - ▪ Vacuum breaker
    - ▪ 3/4-inch NPT inlet
    - ▪ 3/4-inch hose outlet with vacuum breaker
  - o Finish Areas
    - ▪ Polished chrome plated bronze body
    - ▪ Renewable composition disc
    - ▪ Tee handle
    - ▪ 3/4-inch NPT inlet
    - ▪ 3/4-inch hose outlet.
  - o Approved Manufacturers:
    - ▪ Josam
    - ▪ Woodford
    - ▪ Zurn
    - ▪ Chicago Faucet Co
    - ▪ Nibco Inc
    - ▪ Watts Regulator Co.
- Wall and Yard Hydrants
  - o Wall Hydrants
    - ▪ Exposed type non-freeze wall hydrant
      - All brass with polished bronze or nickel bronze face plate
      - "T" handle loose key
      - Integral vacuum breaker
      - Self- draining body and shank

- Exposed ¾ inch male hose thread outlet
- ¾ inch male or female thread inlet
- Renewable seat
- Shank length to extend thru primary exterior wall sufficient distance to prevent freezing.

▪ Flush with wall, non-freeze, box type, wall hydrant

- All brass with polished bronze or nickel bronze box cover and frame
- "T" handle loose key
- Key lock cover
- Integral vacuum breaker
- Self-draining body and shank
- 3⁄4-inch male hose thread outlet
- 3⁄4-inch male or female I.P.S. thread inlet
- Renewable seat
- Shank length to extend thru primary exterior wall surface sufficient distance to prevent freezing

▪ Residential type

- Exposed handle and hose thread
- Frost proof sill faucet
- All brass
- Wheel handle
- Self-draining body vacuum breaker and shank
- Shank length to extend thru primary wall sufficient distance to prevent freezing.

o Yard Hydrants

▪ Flush with grade
▪ Non-freeze
▪ Vertical box type yard hydrant
▪ All brass with polished bronze box cover and frame
▪ "T" handle loose key
▪ Key lock cover
▪ Vandal proof vacuum breaker
▪ ¾ inch male hose thread outlet
▪ ¾ inch male or female I.P.S. thread inlet

        - Self-draining body and shank
    - Approved Wall and Yard Hydrant Manufacturers:
        - Josam Mfg. Co
        - Jay R. Smith, Mfg. Co.
        - Woodford Mfg. Co.
        - Zurn
        - Wade
- Hose Stations
    - Hot and cold-water mixing hose stations exposed
    - Complete with hose, nozzle, hose rack, valves, vacuum breaker, and anchoring.
    - Mixing unit and hose rack to be polished chrome.
    - Approved Manufacturers:
        - Leonard
        - T & S Brass
        - Duco
- Backflow Preventers
    - Install backflow preventers on plumbing lines where contamination of domestic water may occur and on boiler make-up lines, hose bibbs and flush valves.
    - Locate in same room as equipment being connected
    - Pipe relief outlet thru air gap, without valves, to nearest floor drain
    - Vacuum Breaker, Atmospheric Type
        - All brass
        - Angle pattern with disc float that closes the atmospheric vent for temperatures up to 210 degrees F
        - Full size orifice for maximum flow
        - Female thread inlet and outlet
        - Rough brass exterior finish
        - Approved by National Sanitary Foundation
    - Vacuum Breaker Pressure Type
        - Spill resistant design
        - Suitable for indoor or outdoor installation
        - Vent seal diaphragm designed to seal air vent prior to opening the check valve
        - Suitable for use with downstream valves

- Provided with ball valve shutoffs and test cocks

o Double Check Assembly

- Sizes ¾ inch through 2 inches
  - Two spring- loaded, Y-pattern bronze check valves
  - Two bronze ball valves and four test cocks for field testing
  - All valves are threaded type
  - Unit is shipped completely assembled
- Sizes 2-1/2 inches through 10 inches
  - Two spring loaded Y-pattern check valves with epoxy coated ductile iron bodies and bronze trim
  - Two cast iron non-rising stem/OS&Y gate valves and four test cocks for field testing
  - Compact style
  - Inlet flow vertical up
  - Outlet flow vertical down or up as shown on drawings
  - All valves are flanged type
  - Unit is shipped completely assembled
  - Unit to be approved by
    - National Sanitary Foundation
    - U.S.C. Foundation for Cross Connection Control
    - American Society of Sanitary Engineering (A.S.S.E.)
    - State and or Local authorities.

o Reduced pressure type

- Sizes ¾ inch to 2 inch
  - All bronze body
- Sizes 2-1/2 inch to 10 inches
  - Ductile iron body
- Two independently operating, spring loaded check valves and one differential relief valve with automatic intermediate atmospheric vent.
- Pressure in intermediate zone to activate relief valve when there is a 2 psig. Differential between the zone and the upstream side of the first check valve.
- Relief valve shall remain open until a positive pressure differential is re-established.
- Assembly to be furnished with full-port, positive shut off non-rising stem, OS&Y isolation valves, in-line strainer, union connections, funnel, and all test cocks

        - Compact style
        - Inlet flow vertical up
        - Outlet flow vertical down or up.
        - Assembly to have approval of
            - National Sanitary Foundation
            - U.S.C. Foundation for Cross Connection Control
            - A.S.S.E.
            - State and or Local Authorities
    - Carbonated Water for Beverage Dispensing Equipment
        - Stainless steel body and parts
        - Positive double check valve rated for 150 psi at 140 degrees F
        - Heavy duty rubber seats shall comply with FDA food additive regulations.
    - Approved Manufacturers:
        - Febco Sales, Inc.; Subs. of Charles M. Bailey Co., Inc.
        - Watts Regulator Co.
        - Wilkins
        - Ames Company, Inc.
        - Conbraco
- Water Meters
    - Approved Manufacturers:
        - Badger Meter, Inc.
        - Hersey Products Inc.
        - Neptune Water Meter Co.; Subs. Neptune Intl.
        - Rockwell Intl.; Measurement and Flow Control Div.
        - Hays Division; Romac Ind.
- Relief Valves
    - Approved Manufacturers:
        - A.W. Cash Valve Mfg. Corp.
        - Watts Regulator Co.
        - Conbraco Industries, Inc.
        - Wilkins
- Shock arresters
    - Install water hammer arresters in domestic water piping system on each set of flush valves and where hydrostatic shock pressures could occur.

- Provide isolation valve
- Install in accessible location.
- Provide access doors in accordance with architectural recommendations.
- All water connections to equipment with quick closing valves, including, but not limited to:
  - Dishwashers
  - Disposals
  - Clothes washers
  - Ice makers
  - Auto claves
  - Pre-rinse spray hose
  - Other
- Shock Arresters - Bellows Type
  - Stainless steel casing and bellows
  - Rated for 250 psi, 200 degrees F
  - Tested and certified in accordance with PDI Standard WH-201
  - Approved Manufacturers:
    - Josam
    - J.R. Smith Mfg. Co.
    - Woodford
    - Zurn
    - Wade
- Shock Arresters - Piston Type
  - 60 psi pre-charge
  - Sealed from system water with free sliding piston and EPDM O-rings
  - Suitable for up to 150 psi and 180 degrees F
  - Thread connections
  - Approved Manufacturers:
    - Watts Regulator
    - Precision Plumbing Products
    - Sioux Chief

- Water Tempering Valves
  - Pressure Equalizing with Thermometer
  - Concealed type

- 3-port
- All bronze
- Pressure balancing mixing valve with integral check stops
- Maximum temperature limit stop
- Stainless steel balancing piston
- Chrome plated finished wall plate with hot and cold-water marking
- ½ inch or ¾ inch inlet and outlet pipe sizes and volume control
- Unit to hold temperature steady and constant with pressure fluctuations up to 85 percent.
- Unit shall have integral or separate flush with wall
- 3-color dial thermometer with scale from 70 degrees F to 130 degrees F
- Chrome plated trim ring for separate thermometer
- Approved Manufacturers:
  - Leonard
  - Powers
  - Watts
  - Lawler

- Thermostatic Mixing Valves
  - Exposed type
  - All bronze thermostatically controlled mixing valve with stainless steel piston
  - Fail safe automatic shut-down if either hot or cold-water pressure fails
  - Union connection
  - Rough chrome finish.
- Pressure/Temperature Relief Valves (PTRV)
  - Fully automatic
  - All bronze pressure/temperature relief valve with test lever and extension thermostatic element
  - Temperature relief setting at 210 degrees F
  - Pressure setting at 150 psig
  - Meet ASME Standards and comply with the latest AGA ratings
  - Relief opening to be piped to an indirect connection at nearest floor drain
  - Approved Manufacturers:
    - Watts Regulator Co.
- Pressure Reducing Valves

- Approved Manufacturers:
  - Watts Regulator Co.
  - Bell & Gossett
  - Wilkins
  - Mueller
  - Conbraco Industries, Inc.

- Domestic Water Filter - In-Line
  - Duplex Water Filter with type 304 stainless steel housing
  - F-13 activated carbon
  - Replaceable filter sheet
  - 1inch inlet and outlet
  - Provide connections with non-dielectric unions
  - Inlet and outlet valves
  - Full size by-pass with valve
- Vacuum Breakers for Hose Connections
  - Approved Manufacturers:
    - Watts Regulator Co.
    - Cash (A.W.) Valve Mfg. Corp.
    - Conbraco Industries, Inc.
- Domestic Hot Water Expansion Tanks
  - Approved Manufacturers:
    - Bell & Gossett
    - Eaton Metal Products
    - Taco
    - Amtrol
- General Duty Valves
  - Applications
    - Shut-off duty: Ball, and butterfly valves
    - Throttling duty: Globe, ball, and butterfly valves.
  - Sectional Valves
    - On each branch and riser, close to main, where branch or riser serves 2 or more plumbing fixtures or equipment connections
    - 2 inch and smaller, use ball valves
    - 2- ½ inch and larger, use butterfly valves

- Shutoff Valves
  - Inlet of each plumbing equipment item
  - Inlet of each plumbing fixture
  - 2 inch and smaller, use ball valves
  - 2- ½ inch and larger, use butterfly valves
- Drain Valves
  - Each plumbing equipment item
  - Locate to completely drain equipment for service or repair.
  - Install drain valves
    - At the base of each riser
    - At low points of horizontal runs
    - Elsewhere as required to completely drain distribution piping system.
  - 2 inch and smaller, use ball valves
  - 2-1/2 inch and larger, use butterfly valves
- Check Valves
  - Non-slam spring loaded check valves on discharge side of each pump
  - Elsewhere as required
- Balance Cocks
  - In each hot water recirculating loop
  - Discharge side of each pump
  - Elsewhere as required

- Domestic Hot-Water Expansion tanks:
  - Locate in the same room as the water heaters on storage tanks
  - On the cold-water supply line as close to the water heater or storage tank as possible.
  - Installation is to be between the water heater or storage tank and backflow preventer, check valve, pressure reducing valve and/or meter.
  - Provide independent support for in-line mounted tanks.
  - Pre-charge tank to minimum static water pressure at the tank location.
  - Approved Manufacturers:
    - Expansion tanks
      - Bell & Gossett
      - Eaton Metal Products
      - Taco

        - Pressurized expansion tanks:
            - Bell & Gossett
            - Amtrol
            - Wessel

- General Installation
    - Pressure reducing valves to limit maximum static pressure at plumbing fixtures
    - Sleeve and mechanical sleeve seal at penetrations through foundation wall for watertight installation
    - Shutoff valve at service entrance inside building; complete with strainer, pressure gauge, and test tee with valve.
    - Provide thrust blocks on underground water piping at each change in direction
    - Purge and disinfect all new water distribution piping systems and parts of existing systems which have been altered, extended, or repaired; following procedures prescribed by either
        - Authority Having Jurisdiction
        - AWWA C651
        - AWWA C652
- Commissioning
    - Check compression tanks to determine that they are not air bound and that the system is completely full of water.
    - Before operating the system
        - Open valves to fully open position. Close drain, valves, hydrants, and sill cocks.
        - Remove and clean strainers.
        - Check pump for proper direction of rotation. Correct improper wiring.
        - Lubricate pump motors and bearings.

**22 11 23 Domestic Water Pumps**

- Factory-tested, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment.
- Provide pumps of same type by same manufacturer.
- Provide access space around plumbing pumps for maintenance service
- Submittals
    - Product Data
        - Pump specifications
        - Installation, and start-up instructions

- Current accurate pump characteristic performance curves with selection points clearly indicated.

- Shop Drawings
  - Dimensions
  - Weight loadings
  - Required clearances
  - Methods of assembly
- Wiring Diagrams
  - Electrical requirements for power supply wiring to plumbing pumps.
  - Manufacturer's ladder-type wiring diagrams for interlock and control wiring.
  - Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- Maintenance Data
  - Maintenance data and parts lists for each type of pump, control, and accessory
  - Include "trouble-shooting" maintenance guide.
- Closeout
  - Submittals listed above updated to record status

**22 11 23.13 Packaged Booster Systems**

- Factory-fabricated and tested water pressure booster system consisting of diaphragm type water tank, centrifugal pumps, power and control panels, instrumentation, and operating controls.
- 2 pumps, constant speed, single stage, end-suction design, cast-iron, bronze fitted centrifugal pumps with mechanical shaft seals.
  - Mount pumps on vibration isolators
  - Temperature probe and electric purge valve immediately upstream of each PRV
  - Drip proof motors
- Factory-pre-charged diaphragm type water tank with replaceable flexible membrane.
  - Construct in accordance with ASME Code and provide ASME stamp for 125 psi minimum
- Maintain system pressure with pilot- operated diaphragm type combination pressure regulating and non-slam check valve on each pump discharge line.
  - Provide low system pressure switch located on discharge header to sense drop in system pressure, and to activate alarm and automatically start standby pump

- Provide adjustable vane type flow switch to sequence lag pump

- Provide UL-listed, NEMA 1, hinged door, lockable control panel containing the following:
  - For Each Pump
    - Fused disconnect switch
    - Motor starter with 3-leg overload protection
    - Running light
    - Multiple position motor control switch
    - Discharge pressure gauge
  - For System
    - 115-v control transformer
    - Control power switch
    - Indicating lights
    - Relays
    - Visual alarm system
    - Suction pressure gauge
- Factory-prefabricate booster system, mount all components on common structural stand
  - Provide interconnecting piping, isolation valves on suction and discharge of each pump, suction and discharge piping manifolds, shutoff cocks for gauges and pressure switches, and factory-wiring
- Provide electrical and hydraulic test on assembled unit prior to shipment
  - System operating flow test from 0 to 100 percent design flow rate at scheduled suction and discharge pressure conditions.
- Approved Manufacturers
  - Armstrong Pumps, Inc.
  - PSF; Div. Messco Inc.
  - Peerless Pumps
  - Amtrol

**22 11 23.23 In-Line Pumps**

- Horizontal, oil-lubricated, designed for 125 psi working pressure, 225 degrees F (107 degrees C) continuous water temperature, and specifically designed for quiet operation.
- Bronze or stainless-steel construction.
- Steel shaft, ground ,and polished, integral thrust collar

- Two horizontal sleeve bearings designed to circulate oil
- Mechanical seal with carbon brass seal face rotating against ceramic seat.
- Motor: Non-overloading at any point on pump curve, open, drip-proof, sleeve bearings, quiet operating, rubber mounted construction, built-in thermal overload protection.
- Self-aligning, flexible coupling
- Approved Manufacturers
  - Bell & Gossett ITT; Fluid Handling Div.
  - Taco, Inc.
  - Armstrong Pumps, Inc.
  - Dunham-Bush, Inc.
  - Grundfos Pumps Corp.
  - Peerless Pumps

**22 11 23.43 Base-Mounted Pumps**

- Install base-mounted pumps on minimum of 4inch high concrete base equal or greater than 3 times total weight of pump and motor, with anchor bolts poured in place.
  - Set and level pump, grout under pump base with non-shrink grout.
- Base-mounted, double suction pumps
  - Approved Manufacturers
    - Grundfoss
    - Bell & Gossett
    - Taco
    - Armstrong
- Base-mounted, ball-bearing pumps, flexible-coupled:
  - Approved Manufacturers
    - Bell & Gossett

- Vertical turbine pumps:
  - Allis-Chalmers
  - Goulds
- Condensate return units:
  - ITT Domestic
  - Skidmore

**22 12 00 Facility Potable-Water Storage Tanks**

- PROHIBITED

**22 13 00 Facility Sanitary Sewerage**

- Provide flashing for all floor drains, floor cleanouts in wet areas and shower drains above grade
  - Extend flashing at least 24 inches from drain rim into floor membrane or on structural floor
  - Fasten flashing to drain clamp device and make watertight, durable joint.
  - Provide flashing collar extension with all drains and cleanouts installed above grade
- Coordination
  - 33 05 61 Concrete Manholes
  - 33 30 00 Sanitary Sewerage
  - Installation of drains in poured-in-place concrete slabs to include proper drain elevations, installation of flashing, and slope of slab to drains
  - Installation of sanitary sewer systems as necessary to interface building drains with drainage piping systems
  - All penetrations with structural engineer
  - All installations with other trades
- Submittals
  - Product Data
    - Model clearly indicated
    - Operating weights
    - Furnished specialties and accessories
    - Installation instruction
  - Shop Drawings
    - Dimensions, required clearances, and methods of assembly of all components.
  - Maintenance Data:
    - Maintenance data and parts lists for each type of drain, and accessory
    - Include "trouble-shooting" maintenance guide.
  - Closeout
    - Submittals listed above updated to record status

**22 13 19 Waste Piping Specialties**

- Expansion joints
  - Cast-iron body with adjustable bronze sleeve
  - Bronze bolts with wing nuts

- Trap primers
  - Required for equipment room floor drains and other areas as required
    - Bronze body valve with automatic vacuum breaker
    - ½ inch connections matching piping system
      - Inlet ½ inch male NPT
      - Outlet ½ inch female NPT
    - Comply with ASSE 1018.
  - Easily adjusted to high or low pressure and shall be automatically activated whenever any faucet is opened in the building, causing a pressure drop
  - When more than one (1) trap is to be primed, provide one or more distribution units as required by the manufacturer.
  - Install trap primers with piping pitched towards drain trap, minimum of 1/8 inch per foot (1 percent)
  - Adjust trap primer for proper flow
- Flashing Flange
  - REQUIRED for all stacks and cleanouts passing through waterproof membranes
  - Cast-iron watertight stack or wall sleeve with membrane flashing ring
  - Provide underdeck clamp and sleeve length as required
- Vent flashing sleeve
  - REQUIRED on all stacks passing through roof
  - Cast-iron caulking type roof coupling for cast-iron stacks
  - Cast-iron threaded type roof coupling for steel stacks
  - Cast-bronze stack flashing sleeve for copper tubing
- Cleanouts
  - Above Ground Cleanouts:
    - Install in above ground piping and building drain piping as required
    - Extend cleanouts to floor or wall above.
    - Line cleanouts are PROHIBITED.
  - Plugs
    - Cast brass
    - Threads comply with ANSI B2.1
    - Lubricate cleanout plugs with mixture of graphite and linseed oil
    - Remove cleanout plugs, re-lubricate, and reinstall using only enough force to ensure permanent leakproof joint prior to building turnover
  - Floor Cleanout

        - Round, cast iron body with recessed bronze closure plug
        - Scoriated polished bronze frame and cover plate
    - Wall Cleanout
        - Cleanout tee with raised head brass plug tapped for 1/4-20 thread
        - Flat style chrome plated wall cover plate with holes for 1/4inch bolt
            - 1/4-20 threaded bolt with chrome plated flat head
    - Surface Cleanout
        - Cast iron body ferrule with raised head brass plug
        - Medium duty cast iron manhole cover and ring
        - 12inch diameter to be set in concrete pad
    - Line Cleanout
        - Cast iron tapped cleanout ferrule with raised head brass plug
- Approved Manufacturers
    - Josam Mfg. Co.
    - J. R. Smith Mfg. Co.
    - Woodford
    - Zurn Industries Inc; Hydromechanics Div.
    - Tyler Pipe; Subs. of Tyler Corp.
    - Wade
    - Precision Plumbing Products

**22 13 19.13 Sanitary Drains**

- Position drains so that they are accessible and easy to maintain
- Protect drains during construction to avoid clogging with dirt and debris and to prevent damage from traffic and construction work
- Piping left open-ended during construction is PROHIBITED
    - Place plugs in ends of uncompleted piping at end of day or whenever work stops.
- Protect ABS or PVC pipe plumbing vents exposed to sunlight with 2 coats of water-based latex paint
- Floor Drains
    - Install floor drains at low points of surface areas to be drained
    - Set tops of drains flush with finished floor
    - All floor drains are to be provided with P-trap the same size as the floor drain unless required to be different

- Provide flashing membrane for all floor drains in structure above slab on grade level
- Toilet Rooms and Finished Areas
  - Round cast iron body with flashing collar and cast-iron ring
  - 6-inch round nickel bronze adjustable strainer head with secured square hole grate
  - Bottom waste outlet
- Boiler and Mechanical Rooms
  - Round cast iron, light duty, shallow body drain with flashing collar and cast-iron ring
  - 8-inch round tractor type non-tilt slotted grate and sediment bucket
  - Bottom waste outlet
- Sterilizer Drain with Waste Funnel
  - Round cast iron body with flashing collar and cast-iron ring
  - 6-inch round nickel bronze adjustable strainer head with secured square hole grate
  - 6inch x 2 1/2-inch oval nickel bronze waste funnel attached to top grate bottom waste outlet
- Ice Maker or Drip Pan Drain
  - Round cast iron body with flashing collar and cast-iron ring
  - 7-inch round nickel bronze adjustable strainer head with loose set recessed square hole grate
  - Bottom waste outlet
  - Top outside edge of drain to be set flush with finished floor

- Floor Sinks
  - Indirect Waste – Kitchen Equipment
    - Square, cast iron, porcelain enameled interior
    - Sump body drain 6-inch-deep x 8inch square with flashing collar and cast-iron ring
    - 8inch square nickel bronze removable half top grate
    - Dome button strainer
    - Bottom waste outlet
  - Dish Machine - Kitchen
    - Square cast iron, porcelain enameled interior
    - Sump body drain, 16-inch square x 12 inch deep
    - 16-inch square nickel bronze removable half top grate

        - Bottom waste outlet
    - Approved Manufacturers
        - Josam Mfg. Co.
        - J. R. Smith Mfg. Co.
        - Woodford
        - Zurn Industries Inc; Hydromechanics Div.
        - Tyler Pipe; Subs. of Tyler Corp.
        - Wade
        - Precision Plumbing Products

**22 13 19.33 Backwater Valves**

- Where required for interior installations
    - Minimum 13in. dia. cleanout cover flush to floor
    - Centered over backwater valve cover and of adequate size to remove valve cover for service.
- Bronze fitted cast-iron, with bolted cover
- Maximum 1/4inch clearance between flapper and seat for air circulation
- Approved Manufacturers
    - Josam Mfg. Co.
    - J. R. Smith Mfg. Co.
    - Woodford
    - Zurn Industries Inc; Hydromechanics Div.
    - Tyler Pipe; Subs. of Tyler Corp.
    - Wade
    - Precision Plumbing Products

**22 13 23 Interceptors**

- Precast concrete, two compartment, designed for H2O traffic loading
- Water-proofed by manufacturer for continuous interior submergence
- Cast iron manhole rings
- Gas tight manhole cover and frame
- Submittals
    - Product Data
        - Rated capacities of selected models
        - Weights

        - Furnished specialties and accessories
        - Installation and start-up instructions
    - Shop Drawings
        - Dimensions
        - Weights
        - Clearances
        - Methods of assembly
    - Maintenance Data
        - Maintenance data and parts lists for each type of interceptor
        - "Trouble-shooting" maintenance guides.
    - Closeout
        - Submittals listed above updated to record status
- Oil and Sand Interceptors
    - Cast-iron
    - Coated with acid resisting rubber on outside and inside
    - Provide flow control fitting
- Solids Interceptors
    - Cast-iron body
    - Aluminum cover
    - Aluminum sediment basket
    - Removable bronze screws
- Locate so adequate clearance is provided to remove covers and sediment baskets.
- Set recessed units so top of cover is flush with finished floor
- Protect interceptors during construction to avoid clogging with materials, debris, and to prevent damage from construction traffic.
- Approved Manufacturers
    - Josam Mfg Co.
    - J.R. Smith Mfg Co.
    - Zurn Industries; Hydromechanics Div.
    - Rockford Sanitary Systems Corp.
    - Wade Div.; Tyler Pipe

**22 13 29 Sanitary Sewerage Pumps**

- Pedestal Type Sewage Pumps

- Centrifugal, non-clog open grinder type impeller type sewage pump, complete with cast iron inlet strainer, cast-iron base plate, suction plate, and casing, and cast-iron or bronze impeller.
- Shaft: Stainless steel shaft of length to suit depth of basin, connected with flexible coupling to motor upper ball bearings, and intermediate sleeve bearing for lengths over 4 feet and gas-tight packing seal
- Open drip-proof motor
- Fiberglass basin
  - Maintain minimum of 3 feet depth below lowest inlet invert
- Cast-iron or steel circular cover with manhole or hand-hole opening
  - Provide openings for pump, control rod, and discharge piping
- Pump control shall be ball & rod mechanical float switch.
  - Unit consists of copper ball, brass rod & stops
  - Float switch mounted on cast iron pedestal and bolted to sump cover plate.
  - Duplex unit with mechanical alternating float switch complete with high level emergency start position turning on both pumps in case of high liquid level
- System shall include compression type high water alarm complete with alarm buzzer and additional contact for remote signaling.
  - Alarm shall be housed in a NEMA 1 enclosure and mounted on sump cover plate.
- NEMA 1 Control Panel with:
  - UL 508 or CSA approved, main disconnect
  - Thermal & short circuit protection using internal circuit breakers
  - Failure protection with automatic transfer to non-operating pump (duplex system)
  - Control transformer with fused primary (UL 508)
  - Power on and pump run indicating light
  - Hand-off automatic selector switch.
- Approved Manufacturers
  - Liberty
  - Gorman Rupp pumps
  - Zoeller

- Submersible Sewage Pumps

  - Cast-iron shell, bronze grinder type impeller multi-van-semi open capable of passing 3inch solids, stainless steel shaft, factory-sealed grease lubricated ball bearings, ceramic mechanical seal.
  - Motor hermetically sealed NEMA 6, capacitor-start, with built-in overload protection
    - Provide 10' of 3-conductor PVC cord and molded grounding plug.
  - Provide NEMA 1 remote panel with alternator, disconnect for each meter, starters, hand-off-auto selector switch, pilot lights, control transformer and high-water alarm with contacts for remote signaling.
  - Approved Manufacturers
    - Liberty
    - Gorman Rupp pumps
    - Zoeller

- Sewerage Pump Basins and PitsPrecast Concrete Basins and Manholes
  - Approved Manufacturers
    - Copeland
    - Arco
    - Amcor
    - Sanitary Sewer Manholes

**22 14 00 Facility Storm Drainage**

- Coordination
  - 33 05 00 Common Work Results for Utilities
  - 33 40 00 Stormwater Utilities
  - Installation of roof drains, flashing, and roof penetrations
  - Flashing materials installation of roofing, waterproofing, and adjoining substrate work
  - Installation of drains in poured-in-place concrete slabs to include proper drain elevations, installation of flashing, and slope of slab to drains
  - Installation of storm sewer systems as necessary to interface building drains with drainage piping systems
  - All penetrations with structural engineer
  - All installations with other trades
- Submittals
  - Product Data
    - Model clearly indicated
    - Operating weights

- Furnished specialties and accessories
- Installation instruction

o Shop Drawings

- Dimensions, required clearances, and methods of assembly of all components.

o Maintenance Data:

- o Maintenance data and parts lists for each type of drain, and accessory
- o Include "trouble-shooting" maintenance guide.

o Closeout

- Submittals listed above updated to record status

## 22 14 26 Facility Storm Drains

### 22 14 26.13 Roof Drains

- Position drains so that they are accessible and easy to maintain
- Protect drains during construction to avoid clogging with dirt and debris and to prevent damage from traffic and construction work
- Piping left open-ended during construction is PROHIBITED
  - o Place plugs in ends of uncompleted piping at end of day or whenever work stops.
- Roof Drain
  - o Cast iron body with sump
  - o Removable cast iron vandal-proof dome strainer
  - o Cast iron flashing flange and cast-iron ring with integral gravel stop
  - o Underdeck clamp
  - o Match existing for partial replacement projects
- Control Flow Roof Drain
  - o Cast iron body with sump
  - o Removable cast iron/vandal-proof/polyethylene dome strainer
  - o Flashing flange and clamp with integral gravel stop
  - o Cast iron underdeck clamp and cast-iron ring
  - o Flow control assembly with
    - Number of weir openings as required
    - Each weir to have a gpm flow as required
- Parapet Drain
  - o Cast iron body
  - o Vandal-proof cast iron sloping grate

  - Cast iron flashing clamp and cast-iron ring
  - Horizontal/45-degree outlet connection
- Overflow Drain
  - Install overflow roof drains with the inlet flow line located a maximum 2 inches above the lowest point of roof
  - Cast iron body with sump
  - Removable cast iron vandal-proof dome strainer
  - Cast iron flashing flange and cast-iron clamp with integral gravel stop
  - Cast iron underdeck clamp
  - Standpipe with inlet flow line two (2) inches above low point of roof under dome strainer
- Approved Manufacturers
  - J. R. Smith Mfg. Co.
  - Josam
  - Woodford
  - Zurn

**22 14 26.16 Area Drains**

- Coordinate with 33 40 00 Stormwater Utilities
- Stairwells, Walkways and Areaways
  - Round cast iron shallow body drain with square cast iron apron
  - 7-1/2inches diameter
  - Hinged cast iron grate
  - Sediment bucket
  - Bottom drain outlet
- Heavy Duty Drives and Parking Lots
  - Rectangular, heavy-duty cast-iron drain designed for truck or automobile traffic
  - 20-1/2” x 12-1/2” x 12” deep with heavy duty cast iron loose set grate
  - Dome bottom strainer
- Medium Capacity Drives and Parking Lots
  - Square, precast reinforced concrete basin with solid bottom
  - Heavy duty cast iron
  - Removable grate
  - 32" x 32" x 28" deep outside

- 24" x 24" x 20" deep inside dimensions
- Coordinate mechanical plans for outlet pipe size and elevation of outlet and top of grate

- Large Capacity Drives and Parking Lots
  - Rectangular, precast reinforced concrete basin with solid bottom
  - Extra heavy duty cast iron removable grate
  - Top of grate to be flush with top of basin
  - 56" x 36" x 43" high outside
  - 40" x 20" x 35" deep inside dimensions
  - Coordinate mechanical plans for outlet pipe size and elevation of outlet and top of grate
- Catch Basins
  - Heavy Duty Basin with Grate
    - Round, precast, one piece, reinforced concrete basin with solid bottom
    - Inside diameter as required
    - 24" heavy-duty cast-iron grate: top of grate to be flush with top of basin
    - Bottom of basin to be 12 inches below invert of outlet pipe
    - Provide hole in basin wall for outlet pipe
    - Coordinate mechanical plans for outlet pipe size and elevation of outlet and top of grate
  - Light or Medium Duty Basin with Grate
    - Round, reinforced, one-piece, precast concrete with solid bottom and top opening for grate
    - Inside diameter as required
    - Medium duty cast iron grate sized to match
    - Top of grate to be flush with top of basin
    - Bottom of basin to be 12 inches below invert of outlet pipe
    - Provide hole in basin wall for outlet pipe
    - Coordinate mechanical plans for outlet pipe size and elevation of outlet and top of grate
- Approved Manufacturers
  - Josam Mfg. Co.
  - J. R. Smith Mfg. Co.
  - Woodford
  - Zurn Industries Inc; Hydromechanics Div.

- Tyler Pipe; Subs. of Tyler Corp.
- Wade
- Precision Plumbing Products

**22 14 26.19 Trench Drains**

- Cast Iron Trench Drains
  - Shallow hub body and grate with end plates and gaskets
  - Assembled in standard lengths for total length and width as required
  - Features
    - Sediment bucket
    - Flashing device
    - Heel-proof grate
    - Vandal-proof grate
    - Backwater valve
    - Convex grate
    - Dome bottom strainer
    - Bottom outlet
    - Inside calk
- Approved Manufacturers
  - Josam Mfg. Co.
  - J. R. Smith Mfg. Co.
  - Woodford
  - Zurn Industries Inc; Hydromechanics Div.
  - Tyler Pipe; Subs. of Tyler Corp.
  - Wade
  - Precision Plumbing Products
- Non-Metallic Trench Drains
  - Precast polyester resin and quartz aggregate
  - Interlocking design with bottom radius and 0.6 percent slope
  - Load pressure of 14,500 psi
  - Bending pressure of 2,900 psi
  - Frost-proof
  - Salt-proof
  - Inert under dilute acid and alkali conditions and less than 1.0 percent water absorption rate

- Grates either cast iron or steel
  - Heavy-duty truck traffic
  - Openings designed to prevent entry of bicycle or wheelchair tires
- Approved Manufacturers
  - PolyCast
  - Quazite Corp.
  - ACO Drain Inc.

**22 14 29 Sump Pumps**

- Pedestal Type Sump Pumps
  - Centrifugal, enclosed impeller type sump pump, complete with cast iron inlet strainer, cast-iron base plate, suction plate, and casing, and cast-iron or bronze impeller.
  - Stainless steel shaft of length to suit depth of basin, connected with flexible coupling to motor, and intermediate sleeve bearing for lengths over 4 feet.
  - Open drip-proof motor
  - Fiberglass basin
    - Maintain minimum of 3 feet depth below lowest inlet invert
  - Cast-iron or steel circular cover with manhole or hand-hole opening
    - Provide openings for pump, control rod, and discharge piping
  - Pump control shall be ball & rod mechanical float switch.
    - Unit consists of copper ball, brass rod & stops
    - Float switch mounted on cast iron pedestal and bolted to sump cover plate.
    - Duplex unit with mechanical alternating float switch complete with high level emergency start position turning on both pumps in case of high liquid level
  - System shall include compression type high water alarm complete with alarm buzzer and additional contact for remote signaling.
    - Alarm shall be housed in a NEMA 1 enclosure and mounted on sump cover plate.
  - NEMA 1 Control Panel with:
    - UL 508 or CSA approved main disconnect
    - Thermal & short circuit protection using internal circuit breakers
    - Failure protection with automatic transfer to non-operating pump (duplex system)
    - Control transformer with fused primary (UL 508)

        - Power on and pump run indicating light
        - Hand-off automatic selector switch.
    - Approved Manufacturers
        - Swaby
        - Armstrong Pumps, Inc.
        - Ingersoll-Rand Co.
        - Peerless Pump
        - Weil Pump Co.
        - Weinman Pump LFE Corp.; Fluids Control Div.
- Submersible Sump Pumps
    - Cast-iron shell, bronze impeller, stainless steel shaft, factory-sealed grease lubricated ball bearings, ceramic mechanical seal, and perforated steel strainer.
    - Hermetically sealed motor, capacitor-start, with built-in overload protection
        - Provide 10 feet of 3-conductor PVC cord and molded grounding plug.
    - Provide NEMA 1 remote panel with alternator, disconnect for each meter, starters, hand-off- auto selector switch, pilot lights, control transformer and high-water alarm with contacts for remote signaling.
    - Approved Manufacturers
        - Liberty
        - Gorman Rupp pumps
        - Zoeller
        - Hydromatic Pumps
        - Goulds Pumps, Inc.
        - Kenco Pump Div., American Crucible Products Co.
        - Peabody Barnes.
        - Weil Pump Co.
        - Weinman Pump LFE Corp.; Fluids Control Div.
        - Peerless Pumps

## 22 30 00 Plumbing Equipment

### 22 32 00 Domestic Water Filtration Equipment

- Rocky Mountain Aqua Tech

### 22 33 00 Electric Domestic Water Heaters

- RESTRICTED: requires approval of LPS OMC and LPS PM
- In the absence of other information, standards of the following organizations apply
  - Underwriters Laboratory (UL) standards:
    - UL 174, "Electric Storage-Tank Water Heaters"
    - UL 1261, "Electric Water Heaters for Pools and Tubs"
    - UL 1453, "Electric Booster and Commercial Storage Tank Water Heaters"
  - National Sanitation Foundation (NSF)
    - NSF 5, "Standard for Hot Water Generating Equipment for Food Service Establishments using Spray Type Dish Washing Machines"
  - NFPA 70, "National Electrical Code".
  - ASME Boiler and Pressure Vessel Code
  - ASHRAE 90A, "Energy Conservation in New Building Design"
- Provide water heater components which are UL-listed and labeled
- Provide water heaters which are
  - Listed and labeled by National Sanitation Foundation.
  - Water heaters and safety relief valves stamped with appropriate code symbols
- Submittals
  - Product Data
    - Include rated capacities and efficiencies of selected model clearly indicated
    - Operating weights
    - Furnished specialties and accessories
    - Installation and start-up instructions
  - Shop Drawings
    - Dimensions
    - Required clearances
    - Methods of assembly
  - Wiring Diagrams
    - Manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls
    - Differentiate between portions of wiring that are factory-installed and portions that are to be field-installed.
  - Maintenance Data
    - Maintenance data and parts lists for each type and size of water heater, control, and accessory

        - Including "trouble-shooting" maintenance guide
    - Certificates
        - Submit appropriate Certificates of Shop Inspection and Data Report as required by provisions of ASME Boiler and Pressure Vessel Code
    - Closeout
        - Submittals listed above updated to record status
        - Training
            - Manufacturer's technical representative for 1-half day instruction in operation and maintenance of water heaters
            - Provide at least 7-day notice of training date to LPS, contractor, and engineer
- General Installation
    - Units on concrete pads
    - Orient for adequate access and space for maintenance of controls and devices
    - Connect hot and cold-water piping to units with shutoff valves and unions
    - Connect recirculating water line to unit with shutoff valve, check valve, and union
    - Extend relief valve discharge to closest floor drain or other as required
    - Thermometers on inlet and outlet piping of water heaters
    - Install electrical devices furnished by manufacturer but not specified to be factory-mounted
    - Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer
    - Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of other Divisions
    - Do not proceed with water heater start-up until wiring installation is acceptable to water heater Installer
- Warranty
    - Coil, Heat Exchanger, and Burner
    - 5 years from Date of Completion

**22 33 13 Hot Water Dispensers**

- Coordinate with requirements under 22 33 00
- Insulated tank with drain plug
- Chrome-plated faucet
- Instant self-closing valve
- Adjustable thermostat
- 1/2-gallon capacity
- 100 cups of water per hour at 190 degrees F

- Snap action thermostat
  - Adjustable from 140 degrees F to 200 degrees F
  - Factory preset at 190 degrees F.
- 1,300 watts, 115-volts, UL listed; 3-wire cord with NEMA 3-prong grounding plug.
- Approved Manufacturers
  - In-Sink-Erator Div.; Emerson Electric Co.
  - International Technology Sales Corp.

**22 33 30 Residential, Electric Domestic Water Heaters**

- Coordinate with requirements under 22 33 00
- Working pressure of 150 PSI
- Magnesium anode rod
- Glass lining on internal surfaces exposed to water
- Low watt density with zinc plated copper sheath
- Double element non-simultaneous operation
- High temperature cutoff for each element, factory wired
- Full size control compartments with front panel opening
- Insulate tank with vermin-proof glass fiber insulation
- Outer steel jacket with baked enamel finish
- Brass drain valve
- ¾ inch relief valve
- Cold water dip tube
- Thermostat for each element, factory wired
- Approved Manufacturers
  - A. O. Smith Corp.; Consumer Products Div.
  - Rheem Water Heater Div.; City Investing Co.
  - Ruud Water Heater Div.; City Investing Co.
  - State Industries, Inc.

**22 33 33 Light-Commercial Electric Domestic Water Heaters**

- Coordinate with requirements under 22 33 00
- Working pressure of 150 PSI
- Magnesium anode rod
- Glass lining on internal surfaces exposed to water

- Heavy-duty heating elements of medium watt density, with incoloy sheath, and thermostat stepped through magnetic contactors
- Double pole, manual reset, high limit; probe type electric low water cutoff; both factory wired.
- Full size control compartments with front panel opening
- Insulate tank with vermin-proof glass fiber insulation
- Outer steel jacket with bonderized undercoat and baked enamel finish.
- Brass drain valve
- ¾ inch temperature and pressure relief valve
- 4inch x 6inch hand hole cleanout
- Adjustable immersion thermostat
- Power circuit fusing
- Pilot light and switch controlling control circuit
- 3-stage time delay sequencer
- 7-day time clock
- Approved Manufacturers
  - A. O. Smith Corp.; Consumer Products Div.
  - Rheem Water Heater Div.; City Investing Co.
  - Ruud Water Heater Div.; City Investing Co.
  - State Industries, Inc.

**22 34 00 Fuel Fired Domestic Water Heaters**

- In the absence of other information, standards of the following organizations apply
  - Underwriters Laboratory (UL) standards
  - American Gas Association (AGA)
  - National Sanitation Foundation (NSF)
    - NSF 5, "Standard for Hot Water Generating Equipment for Food Service Establishments using Spray Type Dish Washing Machines"
  - NFPA 70, "National Electrical Code".
  - NFPA 54, "National Fuel Gas Code"
  - ASME Boiler and Pressure Vessel Code
  - ASHRAE 90A, "Energy Conservation in New Building Design"
- Provide water heater components which are UL-listed and labeled
- Provide water heaters which are
  - Listed and labeled by American Gas Association and National Sanitation Foundation.

- Water heaters and safety relief valves stamped with appropriate code symbols

- Submittals
  - Product Data
    - Include rated capacities and efficiencies of selected model clearly indicated
    - Operating weights
    - Furnished specialties and accessories
    - Installation and start-up instructions
  - Shop Drawings
    - Dimensions
    - Required clearances
    - Methods of assembly
  - Wiring Diagrams
    - Manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of water heaters and controls
    - Differentiate between portions of wiring that are factory-installed and portions that are to be field-installed.
  - Maintenance Data
    - Maintenance data and parts lists for each type and size of water heater, control, and accessory
    - Including "trouble-shooting" maintenance guide
  - Certificates
    - Submit appropriate Certificates of Shop Inspection and Data Report as required by provisions of ASME Boiler and Pressure Vessel Code
  - Closeout
    - Submittals listed above updated to record status
    - Training
      - Manufacturer's technical representative for 1-half day instruction in operation and maintenance of water heaters
      - Provide at least 7-day notice of training date to LPS, contractor, and engineer

- General Installation
  - Units on concrete pads
  - Orient for adequate access and space for maintenance of controls and devices
  - Connect hot and cold-water piping to units with shutoff valves and unions
  - Connect recirculating water line to unit with shutoff valve, check valve, and union
  - Extend relief valve discharge to closest floor drain or other as required

- Thermometers on inlet and outlet piping of water heaters
- Connect gas supply to gas line with drip leg, tee, gas cock, and union full size of unit inlet connection
- Locate piping so as not to interfere with service of unit
- Connect flue to draft hood with gas-tight connection
- Provide flue of minimum size as flue outlet on heater
- Comply with gas utility requirements

- Warranty
  - Coil, Heat Exchanger, and Burner
  - 5 years from Date of Completion

**22 34 30 Residential Gas Domestic Water Heaters**

- RESTRICTED: requires approval of LPS OMC and LPS PM
- Coordinate with requirements under 22 34 00
- Working pressure of 150 psi
- 3/4inch tapping for relief valve
- Magnesium anode rod
- Glass lining on internal surfaces exposed to water
- Automatic gas shutoff device to shut off entire gas supply in event of excessive temperature in tank
- Pilot safety shutoff
- AGA certified draft hood
- Insulate tank with vermin-proof glass fiber insulation
- Outer steel jacket with baked enamel finish
- Brass drain valve
- ¾ inch relief valve
- Radiant floor shield
- Cold water dip tube
- Gas pressure regulator
- Pilot gas regulator
- Adjustable thermostat
- Approved Manufacturers
  - A. O. Smith Corp.; Consumer Products Div.
  - Rheem Water Heater Div.; City Investing Co.
  - Ruud Water Heater Div.; City Investing Co.

- State Industries, Inc.

**22 34 36 Commercial Gas Domestic Water Heaters**

- Coordinate with requirements under 22 34 00
- Certification of design by AGA under Volume III tests for commercial water heaters for delivery of 180 degrees F (82 degrees C) water
- Working pressure of 150 PSI
- Boiler type hand hole cleanout
- Magnesium anode rod
- Energy efficient as required to meet code
- Tapping for relief valve
- Glass lining on internal surfaces exposed to water
- Automatic gas shutoff device to shut off entire gas supply in event of excessive temperature in tank
- Pilot safety shutoff
- AGA certified draft hood
- Vermin-proof glass fiber insulation
- Outer steel jacket with baked enamel finish over bonderized undercoating
- Brass drain valve
- ¾ inch pressure and temperature relief valve
- Radiant floor shield
- Gas pressure regulator
- Pilot gas regulator
- Thermostat; and temperature limit control
- Approved Manufacturers
  - A. O. Smith Corp.; Consumer Products Div.
  - Rheem Water Heater Div.; City Investing Co.
  - Ruud Water Heater Div.; City Investing Co.
  - State Industries, Inc.
  - Bock Water Heaters, Inc.
  - PVI Industries, Inc.

**22 34 36.16 Packaged Tank and Boiler Commercial Gas Domestic Water Heaters**

- Coordinate with requirements under 22 34 00 and 22 34 36

- Copper tube domestic water boiler factory mounted on top of water storage tank with inter-connection piping and tank circulating pump
- Finned copper tube heat exchanger, lined cast iron or bronze headers, stainless steel burners, integral draft diverter, and spark pilot ignition
- Minimum 81percent thermal efficiency
- Glass lined steel tank constructed in accordance with ASME standards for 150 psig working pressure
- Hand hole
- T&P relief valve
- Foam insulation to exceed ASHRAE 90.1 requirements
- Galvanized steel jacket
- All bronze circulating pump
- Immersion aquastat to start pump and boiler when tank temperature drops below setpoint (140 degrees F-adjustable)
- High limit control
- Approved Manufacturers
  - Lochinvar
  - Ray Pack
  - Teledyne Laars

## 22 40 00 Plumbing Fixtures

### 22 42 00 Commercial Plumbing Fixtures

- In the absence of other information, standards of the following organizations apply
  - ASHRAE Standard 18: "Method of Testing for Rating Drinking Water Coolers with Self- Contained Mechanical Refrigeration Systems."
  - ARI Standard 1010: "Drinking-Fountains and Self- Contained Mechanically-Refrigerated Drinking-Water Coolers"
  - ANSI Standard A117.1: "Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Handicapped People."
  - Public Law 90-480: "Architectural Barriers Act of 1968."
  - UL Standard 399: "Drinking-Water Coolers."
  - Public Law 101-336: "Americans With Disabilities Act
  - NSF Standard 61: "Drinking Water Components."
  - Energy Conservation Act - 1992: "Energy Conservation Standards."
  - Safe Drinking Water Act (42 U.S.C. 300g-6) - Section 1417
- Submittals

- Product Data
  - Submit product data and installation instructions for each fixture, faucet, specialties, accessories, and trim specified; clearly indicate rated capacities of selected models of water coolers
  - Manufacturer's standard color charts for cabinet finishes and fixture colors
- Shop Drawings:
  - Rough-in drawings with brand names on each sheet and item
  - Detail dimensions, rough-in requirements, required clearances, and methods of assembly of components and anchorages
  - Coordinate requirements with Architectural Woodwork shop drawings specified in Division 6 for fixtures installed in countertops and cabinets
  - Furnish templates for use in woodwork shop
- Wiring Diagrams:
  - Manufacturer's electrical requirements and wiring diagrams for power supply to units.
  - Clearly differentiate between portions of wiring that are factory installed and field installed portions.
- Maintenance Data
  - Maintenance data and spare parts lists for each type of manufactured plumbing fixtures, valves, and trim
- Certificates
  - Certification of compliance with specified ANSI, UL, and ASHRAE Standards
- Closeout
  - Submittals listed above updated to record status
  - Extra Stock
    - Furnish special wrenches and other devices necessary for servicing plumbing fixtures and trim to LPS OMC with transmittal signed acceptable receipt to LPS PM
      - Quantity of one device for each 10 fixtures
      - Minimum of one wrench and one device
    - For each type of faucet, furnish faucet repair kits complete with all necessary washers, springs, pins, retainers, packing, O-rings, sleeves, and seats
      - Quantity of 1 kit for each 40 faucets
      - Minimum one repair kit per faucet type

Water Closets

- Vitreous china
- Floor or wall mounted

- Elongated bowl with exception of Children's Toilets
- Where required, support as specified under Fixture Carriers/ Supports
- Siphon jet action
- 1-1/2 inches top inlet spud
- 2-1/4 inches minimum passageway
- 1.6 GPF
- ADA compliant where/as required
- Floor mount with tank additional exceptions and clarifications
  - ADA applications only
  - Close coupled tank
  - Tank cover locking device
  - 2-inch passageway
  - 2 bolt caps
  - Backflow preventer water control with volume regulator
  - Flush valve
    - Trip-lever located on wide side of stall
- Pressure Assist additional exceptions and clarifications
  - Same as Floor mount with tank, except:
    - Pressure assist
    - Not restricted to ADA applications
    - No requirements for trip lever location
- Children's Toilet exceptions and clarifications
  - 10 inches high
  - Floor mounted
  - Round front
  - 2 1/8-inch passageway
- Approved Manufacturers
  - American Standard
  - Kohler
  - Sloan
  - Zurn
  - U.S. Plumbing Products
  - Delaney
  - Eljer

Urinals

- Vitreous china
- Wall mounted
- 1.0 GPF
- Siphon jet action
- ¾ inch top inlet spud
- Flushing rim
- Extended stall sides
- 2-inch outlet connection
- Back and sidewall wash with strainer
- Provide support as specified as specified under Fixture Carriers/ Supports
- ADA compliant where/as required
- Approved Manufacturers
  - American Standard
  - Kohler
  - Sloan
  - Zurn
  - U.S. Plumbing Products
  - Delaney
  - Eljer

Lavatories

- Vitreous china
- Round or oval
- Self Rimming Countertop or Wall Mount
- Front Overflow
- Faucet holes on 4"/8" centers
- With or without soap depressions
- ADA compliant where/as required
- Additional exceptions and clarifications
  - Self Rimming Countertop
    - Fitting ledge
    - Template
    - Sealant
  - Wall Mount

- Integral back
- Made for concealed arm supports
- Provide support as specified as specified under Fixture Carriers/ Supports.

▪ ADA Accessible Wheelchair Lavatory

- Wall mount only
- Faucet holes on 4"/12" centers

o Approved Manufacturers

▪ American Standard
▪ Kohler
▪ Sloan
▪ Zurn
▪ U.S. Plumbing Products
▪ Delaney
▪ Eljer

Showers

o Fiberglass Reinforced Plastic

▪ 36" x 36" x 76" high shower stall
▪ Integral molded base
▪ 2" drain fitting with chrome plated strainer
▪ Coordinate architectural drawings for grab bar reinforcement
▪ Coordinate with all appropriate plan sheets for right or left shower head mounting location
▪ Approved Manufacturers

- American Standard; U.S. Plumbing Products
- Delaney
- Kohler Co.
- Sloan
- Zurn
- Fiat Products
- Aquaglas Universal-Rundle Corp.
- Eljer

▪ Shower and Tub Trim (Thermostatic)

- Approved Manufacturers

- Bradley
- Powers
- Leonard
- Symmons
- T & S Brass

- Shower and Tub Trim
  - Approved Manufacturers
    - American Standard
    - Kohler
    - Powers
    - Chicago Faucets
    - Delta
    - Bradley
    - Symmons
    - T & S Faucets
    - Elier

- Terrazzo Base Only
  - Precast terrazzo
  - 36" x 36" O.D. shower floor
  - Single threshold
  - 2 inch integrally cast stainless-steel drain
    - Removable stainless-steel strainer
  - Coordinate walls and ceiling/shower with architectural requirements to be installed by contractor
  - Color selection by design team and approved by LPS OMC and LPS PM
  - Fiat Style Monterey/Sierra or equivalent by approved manufacturer
  - Approved Manufacturers
    - Arco
    - Fiat
    - Stern-Williams
- ADA Accessible
  - Coordinate all drawings to provide auxiliary/second floor drain outside of shower stall for all handicapped showers.
  - Terrazzo Base Only

- Additional exceptions and clarifications
  - 48" x 48" O.D. shower floor

o Shower Valves and Heads
- Approved Manufacturers
  - American Standard
  - Bradley
  - Chicago
  - Powers

o Column Showers
- Approved Manufacturers
  - Bradley
  - Acorn
  - Symmons
  - Metcraft

Sinks

o Stainless Steel Sinks
- 18 Gauge
- Type 302, 304, or 316 as required for type of program or use
- Thoroughly sound-deadened
- Self Rimming ledge back
- Single Compartment
  - 1, 2, or 3-hole punch as required for faucet
- Double Compartment
  - 1, 2, 3, or 4-hole punch as required for faucets
- Drinking Bubbler
  - With rear, right and left faucet ledges
  - Right/left bubbler ledge
  - Provide 3/4-inch hole punching for faucet and bubbler
- Approved Manufacturers
  - Elkay
  - Zurn
  - Just Mfg. Co.
  - Moen; Div. of Stanadyne

- Plaster Sinks
  - Vitreous china
  - Wall mounted sink with high splash-back, faucet holes on 8" centers
  - Exposed sink support brackets
    - Wall support brackets to be secured as specified under Fixture Carriers/ Supports
  - 2" open grid, chrome plated, all brass drain fitting with 1-1/2inch tailpiece
  - Approved Manufacturers
    - American Standard
    - Kohler
    - Sloan
    - Zurn
    - U.S. Plumbing Products
    - Delaney
    - Eljer
- Utility Sinks
  - Acid resistant
  - Enameled cast iron
  - 8-inch center faucet holes
  - Wall mounted high back sink
    - Wall hangers to be secured as specified under Fixture Carriers/ Supports
  - Counter top mounted with ledge back
    - Flat rim
  - Approved Manufacturers
    - American Standard; U.S. Plumbing Products
    - Kohler Co.
    - Eljer
- Mop Service Basins
  - Precast terrazzo
  - 24" x 24" x 12" deep, O.D., service basin
  - 3 inch integrally cast brass or stainless-steel drain
    - Removable stainless steel or nickel bronze strainer
  - Provide and install stainless steel guards on all sides

- 12inch high to protect walls above rim

- Approved Manufacturers
  - Arco
  - Fiat
  - Stern-Williams

- Laundry Tubs
  - Enameled cast iron
  - Double or Single Compartment
  - 24" x 20" x 14" deep O.D., floor mounted
  - Angle iron supporting frame
  - 2-inch open grid, chrome plated brass drain fitting with 1-1/2inch tailpiece
  - Approved Manufacturers
    - Bradley
    - Intersan/Sanispray
- Service Sink with Trap Standard
  - Acid resistant enameled cast iron
  - 22" x 18" x 11-1/4" deep O.D.
  - Wall mounted sink with wall hangers
  - Stainless steel rim guard
  - Chrome plated brass sink strainer with open grid drain
  - 3-inch cast iron P-trap
    - Enameled interior
    - Painted exterior
    - Floor bracket
  - Approved Manufacturers
    - American Standard; U.S. Plumbing Products
    - Kohler Co.
    - Eljer

Drinking Fountains

- Wall mounted
- Vitreous china
- Push button or lever handle
- Self-closing valve

- Chrome plated anti-squirt bubbler with automatic stream regulation
- ½ inch screwdriver stop
- Chrome plated brass or stainless-steel waste strainer
- Mounting brackets
  - Provide support as specified as specified under Fixture Carriers/ Supports
- Approved Manufacturers
  - Kohler
  - Sunroc Corp.

Wash Fountains

- Precast terrazzo, Terreon, Stainless steel, or molded fiberglass
- Circular or Semi-circular
- Foot or hand operated
- Supply and vent as required
  - Supplies from below and vent off drain
  - Supplies from above and vent thru column
  - Supplies from below and vent thru column
  - Supplies from above and vent off drain
- Provide soap dispenser, liquid, or powder
- Individual spray head for each washing station
- Spray heads operated by either
  - Individual push buttons, one for each station
  - One pushbutton controlling all spray heads simultaneously
- Control valves shall be slow- closing and shall have automatic timed shut-off.
- Brass or copper supply pipes
- Optional or As Needed
  - Stainless steel telescope type shroud to ceiling
  - Spray head with stainless steel supporting tube and bowl gasket
  - Spud with locknut and beehive strainer
  - Mixing valve
  - Volume control valve
  - Two combination soap-strainer and check valves
  - Slow closing foot valve with complete foot operating mechanism
  - Water-saver spray head

- 2-inch cast brass P-trap with integral vent and cleanout
- 2-inch cast iron P-trap below floor.

o Approved Manufacturers

- Bradley
- Equivalent requiring LPS OMC and LPS PM prior to CD submittal

Emergency Equipment

o Eyewash

- Wall mounted
- 13 inches wide x 6-1/2 inches deep
- Vitreous china receptor with integral mounting bracket
- Twin chrome plated brass aerated heads angled to direct water flow into eyes and ocular face area
- Flag push-type ball valve to stay open until manually closed
- ½ inch O.D. supply with loose key stop valve
- Chrome plated
- 1 1/2-inch O.D. tailpiece
- 1 1/2-inch chrome plated cast brass union joint P-trap

o 2. Wall Mounted Twin Head Stainless Steel Bowl Eye Wash

- 10inches dia. x 3inches deep
- Corrosion resistant stainless-steel receptor with wall mounting bracket
- Twin chrome plated anti-squirt heads angled to direct water flow into eyes and ocular face area
- Flag push-type ball valve to stay open until manually closed
- ½ inch O.D. supply with loose key stop valve chrome plated
- 1 ¼ inch O.D. tailpiece
- 1 ½ inch rough chrome plated cast brass union joint P-trap
- Stainless steel wall bracket

o Single Head Countertop Eyewash

- Vertical countertop mounted
- Chrome plated double head eye/face wash to bathe entire face
- Flag push-type ball to stay open until manually closed
- ½ inch O.D. supply with loose key stop valve

o In Wall Mounted Eyewash

- 18-gauge, Type 304 stainless steel cabinet

- Fully recessed with lower locking access door to provide access to stop valve
- Twin chrome plated brass anti-squirt heads angled to direct water flow into eyes and ocular face area
- Water flow to be activated by pulling heads down 90 degrees
- Valve to stay open until manually closed
- ½ inch O.D. supply with loose key stop valve
- Bradley Model S19-520 or equivalent by approved manufacturer.

o Spout Mounted Eyewash

- Faucet mounted eyewash
- Two (2) outlets at 3inch apart and angled forward
- Once activated, water pressure shall hold valve open allowing users hands to be free

o Emergency Shower Mounted Flush with Ceiling

- Ceiling mounted
- Flanged aluminum head with polished face
- 10-inch diameter deluge shower head for mounting flush with ceiling
- Rigid triangular pull rod to actuate instant- action stay-open ball valve
- 1inch O.D. supply
- Support from structure

o Free Standing Floor Mounted Emergency Shower and Eyewash

- All chrome plated brass construction
- 10-inch diameter deluge shower head mounted at 7 feet 0 inches above finished floor
- Eye-wash bowl at 3 feet 6 inches above finished floor
- Shower
  - Rigid pull rod to actuate instant action stay open ball valve
- Eyewash
  - Twin chrome plated anti- squirt heads angled to direct water flow into eyes and ocular face area
  - Flag push- type ball valve actuator
  - Valve to stay open until manually closed
- Unit provided with 1 ¼ inch stand pipe with floor flange
- 1 1/4inch O.D. supply
- 1 1/4inch O.D. waste for eye wash bowl

- Approved Manufacturers
  - Guardian Equipment
  - Haws
  - Speakman
  - Bradley
  - Sloan (Royal)
  - Zurn

Water Coolers

- Wall Mounted Water Coolers /Barrier Free
  - Mounting Options
    - Hanger bracket for wall mounting
    - Frame manufactured of heavy gauge galvanized steel with pre-drilled mounting holes
  - Provide support as specified as specified under Fixture Carriers/ Supports
- Single or High/Low
- Factory assembled and tested, listed, and labeled in compliance with UL Standard 399
- Capacities rated in accordance with ASHRAE Standard 18, and ARI Standard 1010
- Refrigeration System
  - Refrigerant R-134A
  - Hermetically sealed capillary tube
  - All joints lead free silver soldered
  - Compressor
    - Hermetically sealed
    - Automatic reset overload protection
  - Air-cooled Condenser
  - Cooling Unit
    - Tube type
    - Self-cleaning
    - Continuous coil of seamless copper
  - Temperature Control
    - Thermostat with adjustable range of 45 degrees F to 55 degrees F
    - Factory set at 50 degrees F

- Electrical Characteristics
  - 120 volts
  - 60 Hz
  - 3.0 or 4.5 amps
  - 1/6 or 1/5 HP
  - 3-prong power lead-in cord
- Capacity
  - 8.0 to 8.5 GPH of 50 degrees F. water
  - Ambient temperature of 90 degrees F.
  - Entering water temperature of 80 degrees F.
- Bubblers and Valves
  - Chrome plated brass
  - Automatic stream control
  - Push-button valve with bubbler designed to provide uniform stream without spurting
  - Push Bars
    - Plastic is PROHIBITED

o Cabinet Style

- Surface mounted, heavy gauge, welded steel cabinet, with removable front panel and hanger bracket for wall mounting
- Cabinet finish and vinyl color as selected by the architect/engineer and approved by LPS OMC and LPS PM
  - Standard color is a brushed sterling
- Top
  - Deep basin, anti-splash, smoothly contoured stainless steel with raised bubbler mount
- Trap, supply, and stop as specified in Fittings, Trim, and Accessories
- 4-inch air space on both sides of unit for cooling air flow

o Receptor Type

- Receptor
  - Heavy gauge, stainless steel
  - No. 4 finish on the outside
  - Raised bubbler mount
- Stainless steel, one-piece louvered grille matching receptor

- Waste
  - Concealed 1-1/4inch O.D. tailpiece
  - Chrome plated waste strainer
  - 1 ¼ inch I.P.S. trap
- Supply
  - ½ inch I.P.S. screwdriver stop with water strainer assembly

o Bottle Filling Station
- Single ADA Cooler
- High Efficiency
- Non-Filtered
- 8 GPH

o Approved Manufacturers
- Cordley
- Elkay Mfg. Co.
- Halsey-Taylor Div. Household International Co.
- Haws Drinking Faucet Co.
- Oasis
- Sunroc Corp.

Washer Supply and Drain Box

o 9 inches high x 10 ¾ inches wide x 3 5/8 inches deep
o Flush with wall
o Single lever actuated ball valve complete shut-off of hot and cold-water supplies
o 2-inch drain pipe outlet
o ½ inch hot and cold-water inlets
o Water-hammer arrestor
o Approved Manufacturers
- Guy Gray
- Symmons
- Restricted Option
  - Oatey
    - With water hammer arrestor
    - As approved by the LPS OMC and LPS PM

Sink Trim

- Single Compartment Sink Fitting
  - All brass concealed type supply faucet with renewable seats
  - Cover escutcheon
    - One piece or three piece
  - Low Profile Swing Spout
    - 8-inch low profile swing spout
      - Optional aerator outlet
        - 3/4 gpm or 2.5 gpm
    - Acceptable Handles
      - Vandal proof handles
      - Lever handles
      - Cross handles
      - 4inch wrist blade handles
  - Gooseneck Swing Spout
    - 5 3/8-inch x 9 ¾ inch high
    - Acceptable Outlet Options
      - Aerator
      - 3/4 gpm aerator
      - Vacuum breaker and aspirator
      - Flow control or Laminar flow
    - 4-inch wrist blade handles
      - Vandal proof handles as required to meet program or use
  - 1/2inch male thread inlets
  - 8inch on center with coupling nuts
  - Chrome plated exterior finish
  - Strainers
    - Low Profile Swing Spout
      - 3 ½ inch diameter 316 stainless steel basket type strainers
      - Rubber seat stopper
      - 1 1/2inch tailpiece
- Double Compartment Sink Fitting
  - Same requirements as Single Compartment Sink Fitting except as noted
    - Gooseneck Swing Spout

- 8inch x 11-1/4inch high swing spout

- Additional Options
  - Diverter valve in faucet with hose, spray head and deck escutcheon
  - Food Waste Disposer
  - Dishwasher
    - Provide deck mounted vacuum breaker for dishwasher connection or note code requirements for indirect waste connection
- Drains
  - 1 1/2inch 17-gauge tubular brass end or center outlet
  - Continuous waste with cast brass tee flow directing
  - 1-1/2inch tailpiece
  - Chrome plated
  - Dishwasher Option
    - 1-1/2inch tailpiece with 3/4inch Y-connection for dishwasher waste

- Clinical Service Sink
  - Hot & Cold Mixing Faucet
    - Wall mounted
    - Exposed type with hot and cold-water supply
    - Renewable seats
    - Integral stop arms
    - Faucet supply extenders to clear flush pipe
    - 6-inch wrist blade handles
    - 14 ¾ inch stationary spout with plain outlet and pail hook
    - Wall brace below spout with attaching ring for flush pipe and wall bracket
    - ½ inch female thread inlets 8inch on center
    - Faucet and all bracing to be chrome plated
- Classroom Sink
  - All brass, single post, pantry type supply faucet
  - Renewable seats for hot and cold water
  - Gooseneck spout with 3/4 gpm aerator outlet
  - Vandal proof

- Lever handles
- ½ inch male thread inlets with coupling nuts
- Chrome plated exterior finish

o Plaster Sink

- Back mounted, all brass supply faucet
- Brass lever handles
- 5 5/8-inch swing spout with aerator outlet
- Soap dish
- Flanges
- ½ inch female thread inlets
- Chrome plated
- Open Grid Strainer Drain Fitting with 1-1/2inch tailpiece
- Floor mounted solids interceptor with removable cover and strainer basket
  - 13-1/8inch x 13-1/8inch x 16-1/2inch high cast iron
  - Acid resistant coating interior and exterior
  - 2inch chrome plated brass waste piping from sink to interceptor and to waste to wall from interceptor

o Utility Sink Wall Mounted

- Back mounted, all brass supply faucet with lever handles
- 8-inch swing spout with aerator outlet
- Soap dish
- Integral stop arms with flanges
- Integral check valves
- ½ inch female thread inlets
- Chrome plated
- 3-1/2inch diameter drain fitting
  - Flat grid stainless steel
    - 316 stainless steel as required for program application or use
  - Basket type stainless steel
- 1 1/2inch stainless steel tailpiece
  - 316 stainless steel as required for program application or use.

o Mop Service Basin

- Wall mounted, all brass supply faucet

- 10-inch spout with wall brace
- Integral check valve
- ¾ inch male hose thread outlet and vacuum breaker
- Lever handles
- Loose key stops in shanks, wall flanges and 1/2inch female thread inlets
- Chrome plated finish

o Laundry Tub

- Wall mounted, all brass supply faucet
- 12-inch swing spout with aerator outlet
- Wall, or dock flanges and 1/2inch female thread inlets
- Chrome plated finish

o Service Sink

- Back-mount all brass supply faucet with short spout
- Lever handles
- Vacuum breaker
- ¾ inch male hose thread outlet
- ¼ turn lever handle stops in shanks, wall flanges and 1/2inch female thread inlets
- Chrome plated

o Utility Wash Sink

- Lever handles
- 5 ¾ or 8 ¾ inch swing spout
- Vacuum breaker or Aerator as required
- 3/4inch hose thread as required
- Flanged female adjustable supply arms
- 8 inches on center

o Hand Wash Sink

- Double pantry sink fitting with swing gooseneck spout
- Aerator
- Lever handles for hot and cold-water service

Lavatory Trim

o Center Set Faucet

- All brass, one-piece supply faucet with ceramic disk valving
- ½ inch male thread inlets 4 inch on center with coupling nuts,

- Spouts
  - 3 ¾ inch spout
  - 5-inch x 10 5/8-inch gooseneck spout
  - 1/2 gpm aerator outlet
- Vandal proof lever 4inch wrist blade handles
- Chrome plated exterior finish
- Open grid drain assembly
  - Chrome plated brass
  - 1 1/4inch tailpiece
    - ADA applications provided with “offset type tailpiece."

- Wide Spread Faucet
  - Same requirements as Center Set Faucet except
    - 3-piece supply faucet with ceramic disk valving
    - 8 inch on centers with coupling nuts and rigid connectors
    - 4inch spout
- Wheelchair Lav.
  - Same requirements for Wide Spread Faucet, Gooseneck Spout, Wrist Blades, Open Grid Drain except
    - 12 inches on center with coupling nuts and flexible connectors
    - Gooseneck spout 6inches above counter slab
    - 1-1/4inch off-set type tailpiece for wheel chair, chrome plated brass
  - Provide mixing valve or tempered water
  -
- Sensor Faucet for Tempered Water
  - Open Grid Drain per previous requirements
  - Hard-wired PREFERRED
  - Provide tempered water, master mixing valve or below counter type for individual fixture.
  - 4inch center set electronic proximity faucet, vandal resistant, all brass body, below deck mixing valve, built in checks, in-line strainer,/low voltage powered with low voltage transformer, electronically operated solenoid valve with microprocessor, chrome plated finish.
  - (Low Voltage) American Standard No. 6518VP.2AC (1/2 GPM) or equivalent by approved manufacturer
- Approved Manufacturers

- American Standard U.S. Plumbing Products.
- Chicago Faucet Co.
- Delta Workforce
- Kohler Co
- Moen Sani-Stream
- Zurn Industries

Flush Valves

- Approved Manufacturers
  - Sloan (Royal) Valve Co.
  - Zurn Industries, Inc.

Food Waste/Garbage Disposers

- 3/4 hp
- Stainless steel grinding chamber
- Stainless steel shredder
- Stainless steel stopper with anti-splash baffle
- Sound absorbing outer shell
- Overload protection
- 5-year warranty
- Approved Manufacturers
  - In-Sink-Erator
  - National
  - Waste King
  - Hobart

Fixture Carriers/ Supports

- Water Closets ONLY
  - Commercial grade adjustable, factory painted, cast iron face plate, support base, and appropriate type waste fitting having face plate gasket
  - Zinc plated steel fixture studs and fasteners
  - Coated and threaded adjustable wall coupling with neoprene closet outlet gasket
  - Chrome plated fixture cap nuts and fiber fixture washers
  - As required for
    - Deep or shallow rough-in
    - Siphon jet or blow-out action

- Sanitary piping system
- Elevated mounting heights of wheelchair fixtures

- PROHIBITTED installations for all other applications
  - Provide wood blocking/backing
    - Coordinate requirements with 06 10 00 Rough Carpentry
  - Coordinate fastening requirements with LPS OMC and LPS PM for specified mechanical fasters
  - LPS OMC acknowledges this is not an industry accepted standard or practice
    - LPS OMC will sign off on the nonstandard design if requested by engineer
- Approved Manufacturers
  - Josam Mfg. Co.
  - J.R. Smith
  - Wade
  - Zurn
  - Kohler Co.
  - Tyler Pipe

Toilet Seats

- Elongated open front, less cover
- Solid plastic
- High impact
- Commercial weight stainless steel hinge posts self-sustaining check hinge
- Color shall match fixture.
- Approved Manufacturers
  - Bemis Mfg. Co.
  - Church Seats
  - Olsonite Corp.; Olsonite Seats
  - Beneke Corp.

Fittings, Trim, and Accessories

- Supplies and Stops
  - Lavatories, Sinks, and Water Closets
  - Polished chrome-plated
  - 1⁄4 turn lever handle stop
  - ½ inch inlet

- 3/8-inch O.D. x 12inch long flexible tubing outlet
- Wall flange and escutcheon
- Quantity to match trim specified

o Traps
- Drinking Fountains, Lavatories and Bidets
  - 17-gauge tubular brass with clean out
  - 1 ¼ inch adjustable "P" trap and waste to wall
- Sinks
  - Cast brass
  - 1 ½ inch adjustable "P" trap and waste to wall with clean out

o Tub Waste and Overflow Fittings
- 17-gauge brass bath waste and overflow
- Chrome plated waste spud with universal type outlet connection suitable for
  - 1 ½ inch I.P.S.
  - 1 ½ inch O.D. tubing
  - 1 ½ inch solder-joint outlet connection on waste tee

o Escutcheons
- Chrome-plated cast brass with set screw

o Approved Manufacturers
- American Standard
- Brassco
- Chicago
- Kohler

ADA Sink/Lavatory Pipe Insulation

o All ADA Accessible lavatories supplies, and waste shall be insulated with molded vinyl covers.

o Approved Manufacturers
- True Bro
- McGuire
- Lav-Guard
- Approved equivalent insulation kit

Shower Stalls

o Stainless steel, only

- Approved Manufacturers
  - Aquarius
  - Eljer
  - Gerber
  - Kohler

Water Tempering Valves

- Bradley
- Powers
- Watts
- Leonard

Metering Faucets

- PROHIBITTED

## 22 60 00 Gas and Vacuum Systems for Laboratory and Healthcare Facilities

### 22 62 00 Vacuum Systems for Laboratory and Healthcare Facilities

- Vacuum pumps:
  - ITT Pneumotive
  - Lammert
  - Quincy

### 22 66 00 Chemical-Waste Systems for Laboratory and Healthcare Facilities

- In the absence of other information, standards of the following organizations also apply:
  - PDI "Code Guide 302"
  - IAPMO "Uniform Plumbing Code"
- Only personnel who have received training in installation of special piping materials and meet manufacturer's qualifications shall assemble such material.
- Submittals
  - Product data and installation instructions
  - Shop Drawings
    - Scaled layout drawings of laboratory drainage systems piping and fittings including, but not necessarily limited to, pipe and tube sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, cleanouts, expansion joints, adapters, floor drains, and connections.
    - Show interface and spatial relationship between piping and proximate equipment
  - Maintenance data and parts lists
  - Closeout

        - Submittals listed above updated to record status
        - Extra Stock:
        - Furnish sufficient calcium carbonate (marble) chips to replenish charge in acid waste neutralizing sumps one time
        - Store where requested by LPS OMC and forward signed transmittal to LPS PM
- Acid Waste Neutralizing Sumps
    - Submerged type inlet
    - Complete with down pipe or baffle
    - 2" minimum cleanout at top of vertical drop
    - Permanently mark fill line on inside of sump, 1" below outlet invert
    - Approved Manufacturers
        - GSR Fuseal
        - Enfield Industrial Corporation
- Acid Waste Piping and Fittings
    - Design Note: Plastics have low temperature limitations, glass and duriron are subject to fracture due to temperature shock since they are brittle materials, carefully select materials
    - Polypropylene Systems
        - Flame retardant polypropylene DWV piping and fittings meet
            - ASTM D635 flame test
            - ASTM D-1785 dimensional requirements
        - Electric fusion/resistance joints
        - Schedule 40 or 80
        - Provide all fittings, adapters, flanges, plugs, cleanouts, p-traps, drum traps, and tailpieces necessary to make the system complete and operational
        - Manufacturer vertical expansion joints with Viton O-Rings for vertical risers where required to compensate for expansion and riser movement.
        - P-traps shall have mechanical joints for easy dis-assembly for maintenance
        - Approved Manufacturers
            - GSR Fuseal
            - Enfield Industrial Corporation
    - High Silicon Cast Iron Pipe Systems
        - Service weight
        - 14 ½ percent high silicon content cast-iron
        - Pipe sizes 4 inches and smaller

- Hub-less fittings
- Stainless steel 2-bolt couplings with one-piece sintered non- porous Teflon inner sleeve liner

▪ Pipe sizes 6 inches and larger

- Ball and spigot fittings
- Lead and special acid-resistant rope packing
- Caulked joints

▪ Provide all fittings, adapters, flanges, plugs, cleanouts, p-traps, drum traps and tailpieces necessary to make the system complete and operational

▪ Approved Manufacturers

- The Duriron Company
- Approved Equal

o Glass Pipe Systems

▪ U.L. classified borosilicate glass conforming to ASTM specification C1053-85

▪ Piping system shall include all straight pipe lengths, fittings, p-traps, drum- traps, compression type tetra-fluoro-ethylene lined couplings and padded hanger supports

▪ Glass to glass connections shall be made with compression type bead to bead and bead to plain end couplings

▪ Coupling outer shell, bolt and nut shall be 300 series stainless steel.

▪ Bead to plain end coupling onto shell must encapsulate compression liner to prevent cold flow and ensure leak-free joint

▪ Seal ring gasket shall be TFE

▪ Joints shall be capable of being leak free with deflection angle up to 4 degrees

▪ Provide engineered and manufactured adapter connectors where joints between glass and other piping material/systems are made

▪ For 8" glass pipe and fittings, provide flanged ends assemblies with TFE gaskets

- Sealing surface of the glass shall be spherically ground in the form of a ball and socket configuration
- Ball and socket flanges shall be capable of a 3-degree misalignment leak-free and stress-free

▪ Glass pipe installed, buried below grade shall be covered with factory applied expanded polystyrene protective covering.

▪ Approved Manufacturers

- KIMAX/SCHOTT Process System, Inc.
- Corning Process Systems

- All acid waste and vent piping system installations, regardless of material type, shall have on site factory trained and authorized supervision made available to the contractor on a regular basis throughout the installation process
- Each pipe and fitting system manufacturer shall conduct field inspections of product installation not less than once a week and provide a typed report to the architect/engineer confirming the product is being properly installed in accordance with manufacturer's requirements
- Failure to provide reports to the architect/engineer is subject to withholding payment per the General Conditions
- Provide and install UL listed firestop and sealant systems for all piping penetrating fire rated walls, floors, or roof systems
- All below grade buried acid waste and vent piping shall have trenching, backfill and compaction in accordance with Section 15010 and as specifically required by each manufacturer's written installation instructions
- Provide all necessary pipe fittings and/or offsets necessary for proper expansion control as recommended by the pipe material manufacturer
- Install acid waste and vent piping systems as indicated in the table below:

| ACID WASTE & VENT PIPE SYSTEM APPLICATIONS TABLE | |
|---|---|
| APPLICATION | PIPE SYSTEM |
| All sizes, below grade (Buried), INSIDE the building | Duriron or Polypropylene |
| All sizes, below grade (Buried), OUTSIDE the building | Duriron |
| Sizes 4” and smaller, above grade, INSIDE the building | Duriron or Polypropylene or Glass |
| Sizes 6” and larger, above grade, INSIDE the building | Duriron or Glass |
| All sizes serving equipment (including indirect drains) discharging waste at temperatures above 120° F (Including but not limited to Glasswashers, Dishwashers, Cage Washers, Cart Washers, Autoclaves, etc.) | Duriron or Glass |

- Cleanouts
  - As required by plumbing code
  - At each change in direction of piping greater than 45 degrees below slab

  - At sinks
  - At each upper terminal
  - At egress of building (surface cleanout)
  - Select cleanout locations and access for minimum disturbance of occupant functions and building systems operation during cleanout servicing
  - Confirm architect, LPS PM, and LPS OMC agree with location and appearance
  - Avoid conflicts with shelves, mirrors, and any other architectural obstructions
  - Install cleanouts above all sinks (42inches AFF or at least above flood level of lav.)
  - Install cleanouts 6inches above highest trap on that floor on the main vent of each group of fixtures and in vent stacks for isolated fixtures on each floor
  - Install cleanouts of full size at top and base of each stack and at end of each horizontal run
  - Do not exceed 40 feet on horizontal runs
  - Provide cleanout plugs line-size up to 3inches, 4inches for line sizes 4inches and larger
  - Specify wall cleanouts where piping is concealed in walls or non-accessible chases, 42inches AFF
- Cleanout Covers
  - Install floor and wall brass or chrome plate cleanout covers for concealed piping
  - Types as indicated in Section 22 13 00 and in accessible locations
- Flashing Flanges
  - Install flashing flange and clamping device with each cleanout passing through waterproof membrane
- Acid Waste Neutralizing Sumps
  - Fill sumps up to fill line with 1inch calcium carbonate (marble) chips
- Connection to Building Sewer
  - At point of connection of laboratory drainage piping system to building sewer, provide T-Wye of same material as laboratory drainage piping
- Drain Connections to Fixtures & Mechanical Equipment
  - Provide drain piping and traps for each fixture indicated to be connected to laboratory drainage system
- Clean, flush, and inspect laboratory drainage systems to ensure systems are functioning properly

**END OF DIVISION 22**

# DIVISION 23 HEATING, VENTILATING and AIR CONDITIONING (HVAC)

## 23 00 00 General HVAC Requirements

- In the absence of any other information, work shall be provided in accordance with the following codes, rules, regulations, and ordinances
  - SMACNA
  - ASHRAE
  - Colorado Energy Conservation Code
  - IBC
  - NFPA
  - EPA
  - OSHA
  - Underwriters Laboratories (UL)
  - Local Public Utilities
  - Cities of Littleton and Centennial
  - Arapahoe and Jefferson Counties
  - Other State of Colorado codes, ordinances, and regulations
  - Littleton Public Schools (LPS) special requirements
- Licensed craftsmen shall always be on-site while work of their trade is being performed, with licenses in their possession to be presented upon request as required by regulations
- Systems shall have night-time free-cooling capabilities
- Systems shall be sound isolated to a maximum 45dB background noise level within occupied space(s), in accordance with CDE standards and ANSI S12.60.2010.
- Temperatures in occupied spaces shall adhere to LPS Board of Education policy
  - Occupied Space Temperatures
    - Cooling Season shall be maintained between 76° and 79° Fahrenheit (F)
    - Heating Season shall be maintained between 67° and 71° F
  - Un-occupied Space Temperatures
    - No lower than 55° F
- Mechanical Cooling
  - All equipment to meet Colorado Regulation 15
  - Shall be selected as most appropriate and cost-effective for specific building conditions

- Where central plant chillers do not exist, or connection is not practical, especially where no mixed-air ducted distribution exists or is feasible
  - REQUIRED review and approval of alternate solutions with LPS OMC and LPS PM
  - Preferred options
    - DX cooling
    - Roof-top package units (RTUs)
  - Heat pumps or active chilled beam systems may be considered, with written approval from LPS OMC and LPS PM

- Heating and Cooling Systems
  - Shall furnish positive ventilation and comply with current ASHRAE standards
  - Projects with or without mechanical cooling shall have provision for introducing up to 100 percent outside air when heating is not required.
- High Velocity Air System(s)
  - Shall not be provided without mechanical cooling
- Heat Source
  - Hot water
  - Gas-fired unit(s)
- Direct Fired Heat Exchangers
  - PROHIBITED
- Basic Heating and Ventilating Equipment
  - Central station
  - Rooftop
  - Ground-set NOT PREFERRED
  - Unit ventilators PROHIBITED in new construction
- Supplemental Heating
  - Unit Heaters
  - Cabinet heaters
  - Radiation
  - Other sources as approved by LPS OMC and LPS PM.
- Electric Heat
  - RESTRICTED
    - Requires written approval of LPS OMC and LPS PM
- Exhaust
  - Provide through relief opening(s) or fan(s).

  - Wherever space(s) require exhaust air only, provide make-up air from areas of the building, as permitted by code

- Supply, Return, Exhaust Air Systems
  - Variable volume, variable temperature supply air distribution is preferred.
  - Design and balance systems so that the building shall always have slight positive pressure.
    - SPECIAL ATTENTION: Economizer mode
  - Air Ventilation Rates must meet current ASHRAE standards and applicable building codes.
- Ventilation Requirements
  - Conform to latest edition(s) of the IBC, locally applicable Building Codes, and Colorado Energy Conservation Code.
    - Requirements contained therein will be considered as minimum.
- Independent HVAC
  - Systems provided for Administration areas (and other areas as designated by LPS) shall be separate from primary building HVAC systems, with central controls override afforded via on-site timer switch(es).
- Maintenance and Operation Manuals
  - One printed copy and one PDF copy of Operation and Maintenance manuals shall be furnished to LPS on completion of and prior to LPS acceptance and payment for installation
  - LPS OMC representatives shall be instructed on proper operation and maintenance of all systems using the manuals as a guide
  - Furnish detailed written instructions for Custodial and Maintenance personnel spelling out daily, weekly, monthly, and yearly requirements
  - Deficiencies in mechanical installations and equipment will be corrected during the first year of operation (or as designated by extended warranty or legal obligation) at no additional cost to LPS
- Alternating/Stand-by Pumps to be provided in main Heating Circulating systems
  - Pumps should: be sized slightly above performance curve; be properly supported; not be close-coupled; have bronze impellers for domestic side, iron impellers for heating side; include valved by-pass as feasible; include isolation valves at gauges; include back-up or stand-by for main or boiler pumps; have temperature/pressure gauge(s) at main circulation pumps; be easily accessible for operation, maintenance and replacement and not be installed overhead
- Evaporative Cooling
  - RESTRICTED
    - Requires written approval of LPS OMC and LPS PM
- Environmental

  - Air conditioning requirements shall accommodate computer installations as specified under Divisions 27 and 28

- Equipment, Motors, and Controls
  - Associated with addition and remodel areas will be the same manufacturer(s) as existing and/or shall comply with the LPS list of acceptable products
  - Motors should: be energy-efficient; have sealed bearings; not be split-phase; be variable-speed if 10 hp or larger, except as approved by LPS OMC and LPS PM
  - Thermostats/controls should be accessible and have copper lines in exposed areas and where temperature is a factor
- Automation Sensors
  - Shall be provided on designated equipment by the Mechanical Contractor, coordinated with LPS OMC and LPS PM
- A/E responsibilities
  - Include defining contractor responsibilities relative to existing LPS automation connection points
  - The A/E is responsible for coordinating instructions with LPS OMC before specifications are completed and ready for bid and construction
- Temperature Control Systems and Equipment
  - Match existing LPS Direct Digital Control (DDC) systems and equipment by Johnson Controls
  - New equipment shall include factory-installed DDC modules, field-connected to Metasys NCU provided by Johnson Controls
  - Control of existing equipment shall be maintained via existing Johnson Control devices and field modified as required
  - Field level controls are to be BACnet MSTP compatible and interface with the existing JCI ACX Platform
- Electrical Temperature Control Systems
  - Shall be installed in accordance with Section 23 09 23 and applicable sections of Division 26
- Boiler and Gas Line Work
  - Work on gas lines on or near building(s) while building is occupied is PROHIBITED
  - Work on boilers, furnaces, or gas lines REQUIRE 72-hour prior notification and approval of, and coordination with LPS OMC
  - PROHIBITED: Start up and/or shutdown of LPS equipment
    - LPS boilers or furnaces are to be turned on or off by LPS OMC
    - Department will be notified, and appropriate personnel will be dispatched to carry out necessary procedures

  - Boilers shall: be energy-efficient; be dual-burner types (natural gas) at high schools; be forced-draft wherever possible; include an automatic make-up water system with in-line flowmeter, odometer/dial readout and pulse output option for both local and remote indication

- Valves and Valved Systems
  - Shall have the ability to isolate zones (supply and return); be accessible; contain a midway isolation valve where feasible; have isolation valves installed on each side of individual equipment, especially circulation pumps; have main valves color-coded; have manual air-bleeds piped to ground/floor level and automatic bleeds valved; have no iron plug valves; have no dielectric unions (brass only); have dielectric nipples
- Energy Conservation
  - Standards of Colorado, latest edition, will be followed in the design of Heating and Cooling Systems with cross-reference to Electrical Energy utilized
  - Life Cycle Costing (LCC) for base systems (air, water, electrical, gas) and any proposed alternates shall be researched and reported in Design Development documents submitted for review and approval

## 23 05 00 Common Work Results for HVAC

- Contractor to coordinate with LPS OMC and LPS PM for all new to existing connections, system shutdowns and restart-up, flushing and filling both new and existing systems.
- Temporary services to be shown on the drawings
  - Include temporary ductwork and piping services where required to maintain existing areas operable
- All services shutdown to comply with 01 18 00 Project Utility Sources
- Contractor shall be responsible for the maintenance operation and servicing of all new mechanical systems which are to be used by LPS during the time of any occupancy and use of any areas within the construction limitations before final completion or acceptance of the systems.
  - A written record of maintenance, operation and servicing shall be turned over to LPS PM prior to final acceptance.
- Install equipment and materials to provide required access for servicing and maintenance
  - Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors
  - Allow ample space for removal of all parts that require replacement or servicing
  - Extend all grease fittings to an accessible location
  - Furnish hinged steel access doors with concealed latch in all walls and ceilings for access to all concealed valves, shock absorbers, air vents, motors, fans, balancing cocks, and other operating devices requiring adjustment or servicing
    - Coordinate Section 08 31 00 for access door specification and Divisions 23 for duct access door requirements.
    - The minimum size of any access door shall not be less than the size of the equipment to be removed or 12 inches x 12 inches if used for service only.
    - All doors are REQUIRED to be labeled indicating what is behind the access door.
    - Furnish doors to trades performing work in which they are to be built, in ample time for building-in as the work progresses.
    - Whenever possible, group valves, cocks, etc., to permit use of minimum number of access doors within a given room or space.
    - Factory manufactured doors shall be of a type compatible with the finish in which they are to be installed. In lieu of these doors, approved shop fabricated access doors with DuroDyne hinges may be used.
    - Access doors in fire-rated walls and ceilings shall have equivalent U.L. label and fire rating.

- Utility construction/installation costs to include all valves, valve boxes, meter boxes, meters, and such accessory equipment for
  - Natural gas hookup and installation fees
  - Water meter
  - Water and sewer tap fees (excluding development fees) and associated piping and fittings
  - Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.
- Coordinate the installation of mechanical materials and equipment above and below ceilings with suspension system, light fixtures, and other building components.
  - In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of priority
    - Plumbing waste, vent piping and roof drain mains and leaders
    - Supply, return and exhaust ductwork
    - Fire sprinkler mains and leaders
    - Electrical conduit
    - Domestic hot and cold water
    - BAS Control Piping or Wiring
    - Fire sprinkler branch piping and sprinkler runouts
- Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components
  - Connect equipment for ease of disconnecting, with minimum of interference with other installations.
- Pipe Trenching
  - Install 6-inch bed of pea gravel or squeegee
  - Mechanically tamp to provide a firm bed for piping
- Trench Backfill
  - Shall not be started until all work has been inspected, tested, and accepted by A/E, LPS OMC and LPS PM
  - All backfill material shall be reviewed by the soils engineer
    - Lumber, metal, or other debris is PROHIBITED from backfill
  - Provide warning tape for marking and locating underground utilities
    - For exterior underground system only
    - Provide continuous inscription naming the specific utility

        - Tape shall have magnetic strip
    - Backfill to 12 inches above top of piping with pea gravel or squeegee, the same as used for piping bed, compact properly
    - Complete the backfilling near manholes using pea gravel or squeegee, installing it in 6-inch lifts and mechanically tamping to achieve 95 percent compaction.
- Coordinate cutting and patching of mechanical equipment, components, and materials to include removal and legal disposal of selected materials, components, and equipment with
    - LPS General Conditions
    - LPS section 01 23 79 Cutting and Patching
    - Other sections of LPS Construction Standards as required
- Coordinate temporary facilities with
    - LPS General Conditions
    - LPS section 01 51 00 Temporary Utilities
    - Other sections of LPS Construction Standards as required
        - Where equipment is used for temporary heating or cooling, it shall be adequately maintained per manufacturer's instructions and protected with filters, strainers, controls, reliefs, etc.
        - Hydronic systems shall be flushed and chemically treated.
        - All filters required for the construction period shall be equivalent to the filters required for the final installation
        - All filters shall be replaced at the time of substantial completion
        - Guarantee period of all equipment used shall not start until the equipment is turned over to LPS for use
- Submittals
    - Provide submittals for each item of equipment specified or scheduled in the contract documents per table at the end of this section.
    - Product Data:
        - Mark submitted copy with black pen to indicate which of the variations is to be provided.
            - Delete or mark-out portions of pre-printed data which are not applicable.
            - Where operating ranges are shown, mark data to show portion of range required for project application.
        - For each product, include the following
            - Sizes

- Weights
- Speeds
- Capacities
- Piping and electrical connection sizes and locations
- Statements of compliance with the required standards and regulations
- Performance data
- Manufacturer's specifications

o Shop Drawings to include

- Clearance dimensions at critical locations.
- Dimensions of spaces required for operation and maintenance
- Show interfaces with other work, including structural support.

o Test Reports

- Signed and dated by the firm performing the test.
- Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated

o Testing and Balancing (TAB) report

- Upon completion of project work, all necessary adjustments shall be made to test and balance Heating and Cooling air and hydronic systems
- Submit TAB report to the engineer at least fifteen calendar days prior to the contractor's request for final observation time frame requirements
  - Include in the O & M Manual after review with "No Exceptions Taken"
- A complete written report of systems operations shall be furnished to the LPS Operations, Maintenance and Construction Department (OMC) and LPS Project Manager (PM) with data sheets indicating amount of air handled, room temperatures, exterior weather data, equipment data, and other pertinent data
- The same procedure will be repeated during the first winter and first summer after occupancy at no additional cost to LPS
- LPS reserves the right to confirm HVAC testing and balancing by a separate contractor working directly for LPS

o Operation and Maintenance Data

- Description of mechanical equipment, function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.

- Manufacturer's printed operating procedures to include start-up, break-in, routine, and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
- Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
- Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.
- Manufacturer's service manuals for all mechanical equipment provide under this contract.
- Include the valve tag list.
- Name, Address and Telephone number of party to be contacted for 24-hour service for each item of equipment.
- Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment
- Complete parts list
- Mechanical warranties

o Closeout

- Submittals listed above updated to record status
- REQUIRED Electronic copy of redline drawings for BAS Control Wiring
- Warranties
  - Coordinate with
    - LPS General Conditions
    - 01 77 00 Closeout Procedures
    - 01 78 00 Closeout Submittals
    - 01 78 36 Warranties
  - Refer to individual equipment specifications for warranty requirements

- Prepare listing of major mechanical equipment and materials for the project within (2) two weeks of signing the Contract Documents per table at the end of this section
- When multiple items of the same type equipment are required (e.g., plumbing fixtures, pumps, valves, gauges, fans) they shall be of the same manufacturer
- Provide permanent operational data nameplate on each item of mechanical equipment, in accessible locations, indicating
  - o Manufacturer
  - o Product name
  - o Model number

  - Serial number
  - Capacity
  - Operating and power characteristics
  - Labels of tested compliances
  - Similar essential data
  - LPS OMC and LPS PM review and approval of all naming conventions is REQUIRED prior to procurement
- Delivery, Storage, and Handling
  - Provide factory-applied plastic endcaps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-spigot, clay pipe
    - Maintain endcaps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture
  - Protect stored pipes and tubes
    - Elevate above grade and enclose with durable, waterproof wrapping
    - When stored inside, do not exceed structural capacity of the floor
  - Protect flanges, fittings, and specialties from moisture and dirt by inside storage and enclosure, or by packaging with durable, waterproof wrapping
- Properly lubricate all mechanical pieces of equipment before turning the building over to LPS
  - Attach a linen tag or heavy-duty shipping tag on each piece of equipment showing the date of lubrication and the type and brand of lubricant used.
  - Furnish a typewritten list of each item lubricated and type of lubricant
- Coordinate 02 42 21 Salvage of Construction Materials to include returning the following materials and equipment to LPS
  - Existing thermostats and humidistats
  - BAS controls and controllers
  - Existing control valves and devices
  - Existing humidifiers and control valves
  - Existing plumbing fixtures
  - Return existing unused/not relocated ceiling diffusers
- Mechanical Checklist
- Review and edit the following matrix carefully and include X's in boxes where needed and include in Project Manual

CONTINUED ON NEXT PAGE

| SPEC SECTION | ITEM | REQUIREMENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SUBMITTALS | | | SUPPLEMENTAL | | FACTORY REP SUPER-VISION AT SITE | **TRAINING REQ=D AT SITE | **EXTRA MATERIAL | At completion of project obtain Owner's sign off that the following has been received: | | |
| | | Shop drawings | Product Data | Include in O & M | TEST | REPORT | | | | Training of Product | Extra Materials | Document |
| 23 05 00 | SCHEDULE OF VALUES | | | X | | X | | | | | | |
| 23 05 00 | EQUIPMENT WARRANTIES | | | X | | | | | | | | |
| 23 05 00 | O&M MANUALS | | | | | | | | | | | |
| 23 05 00 | COORDINATION DRAWINGS | X | | | | | | | | | | |
| 23 05 00 | RECORD DRAWINGS | X | X | X | | | | | | | | |
| 23 05 13 | MOTORS, STARTERS AND DRIVES | X | X | X | X[4] | X | X[5] | | | | | |
| 23 05 13 | VARIABLE SPEED DRIVES | X | X | X | X | X | X | X | X | | | |
| 20 05 18 | MECHANICAL SYSTEMS FIRE STOPPING | | X | X | | | | X | | | | |
| 23 20 00 | BASIC PIPING MATERIALS | | X | X | X | X | | | | | | |
| 23 25 00 | PIPE FLUSH/CLEAN | | | X | X | X | | | | | | |
| 23 25 00 | PIPE DISINFECTION (POTABLE $H_20$) | | X | X | X | X | | | | | | |
| 22 60 00 | SPECIAL PIPING SYSTEMS | X | X | X | X | X | X | | | | | |
| 22 66 00 | LAB DRAINAGE SYSTEMS | X | X | X | X | X | X | | | | | |
| 23 05 23 | VALVES | | X | X | | | | | | | | |
| 23 21 16 | PIPING SPECIALTIES | | X | X | | | | | | | | |
| 23 05 16 | PIPE EXPANSION JOINTS | | X | X | | | | | | | | |
| 23 05 19 | METERS AND GAUGES | | X | X | | X[6] | | | X | | | |
| 23 05 29 | SUPPORTS AND ANCHORS | X | X | X | | | | | | | | |
| 23 05 53 | MECHANICAL IDENTIFICATION | | X | X | | | | | X | | | |
| 23 05 48 | VIBRATION CONTROL | X | X | X | X | X | | | | | | |
| 23 05 48 | MECHANICAL INSULATION | | X | X | | | | | | | | |
| 21 10 00 | FIRE PROTECTION | X | X | X | X | X | | X | X | | | |
| 21 30 00 | FIRE PUMPS | X | X | X | X | X | | X | | | | |
| 22 11 00 | WATER DISTRIBUTION PIPING | | X | X | X | X | | | X | | | |

| SPEC SECTION | ITEM | REQUIREMENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SUBMITTALS | | | SUPPLEMENTAL | | FACTORY REP SUPER-VISION AT SITE | **TRAINING REQ=D AT SITE | **EXTRA MATERIAL | At completion of project obtain Owner's sign off that the following has been received: | | |
| | | Shop drawings | Product Data | Include in O & M | TEST | REPORT | | | | Training of Product | Extra Materials | Document |
| 22 13 00 | DRAINAGE & VENT SYSTEMS | | X | X | X | X | | | | | | |
| 22 42 00 | PLUMBING FIXTURES | | X | X | | | | | X | | | |
| 22 11 23 | PLUMBING PUMPS | | X | X | | | | | | | | |
| 22 12 00 | STORAGE TANKS | | X | X | X | | | | | | | |
| 22 31 00 | WATER TREATMENT(Dom.) | X | X | X | X | X | | X | X | | | |
| 22 31 00 | TREATMENT CHEMICALS | | | X | | | | | X | | | |
| 22 31 00 | WATER SOFTENER | | | X | X | X | | | X | | | |
| 22 31 00 | SYSTEM CLEANING[1] | | | X | X | X | | | | | | |
| 23 25 00 | WATER TREATMENT(Hyd.) | X | X | X | X | X | | X | X | | | |
| 23 25 00 | BOILER CLEANING | | | X | | X | | | | | | |
| 22 34 00 | WATER HEATERS | | X | X | | | | X | | | | |
| 22 13 23 | INTERCEPTORS | X | X | X | | | | | | | | |
| 22 66 00 | LAB DRAINAGE SYSTEMS | X | X | X | X | X | | X | X | | | |
| 23 11 23 | NATURAL GAS SYSTEMS | | X | X | X | X | | | X | | | |
| 23 23 00 | GLYCOL SYSTEMS | | X | X | X | X | | X | X | | | |
| 23 21 00 | HYDRONIC SPECIALTIES | X | X | X | X | X | | | | | | |
| 23 22 23 | CONDENSATE PUMP & REC. SETS | | X | X | | | | | | | | |
| 23 23 16 | REFRIGERANT PIPING SPECIALTIES | | X | X | | | | | | | | |
| 23 21 23 | HVAC PUMPS | | X | X | | | | | | | | |
| 23 52 00 | BOILERS | | X | X | | X | X | X | | | | |
| 23 53 00 | BOILER ACCESSORIES | | X | X | | | | | | | | |
| 23 51 00 | BREECHINGS, CHIMNEYS & STACKS | X | X | X | | | | | | | | |
| 23 53 00 | FEEDWATER EQUIPMENT | | X | X | | | X | X | | | | |
| 23 53 00 | DEAERATORS | | X | X | | | | X | X | | | |

| SPEC SECTION | ITEM | REQUIREMENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SUBMITTALS | | | SUPPLEMENTAL | | FACTORY REP SUPER-VISION AT SITE | **TRAINING REQ=D AT SITE | **EXTRA MATERIAL | At completion of project obtain Owner's sign off that the following has been received: | | |
| | | Shop drawings | Product Data | Include in O & M | TEST | REPORT | | | | Training of Product | Extra Materials | Document |
| 23 54 00 | FORCED AIR FURNACES | | X | X | | | | | | | | |
| 23 62 00 | CONDENSING UNITS | | X | X | | X[1] | X | X | | | | |
| 23 81 43 | AIR SOURCE HEAT PUMPS | | X | X | | X | X | X | | | | |
| 23 64 16.13 | CENTRIFUGAL CHILLER-AIR COOLED | | X | X | X | X | X | X | | | | |
| 23 64 16.16 | CENTRIFUGAL CHILLERS - $H_2O$ COOLED | | X | X | X | X | X | X | | | | |
| 23 64 19 | RECIPROCATING CHILLERS | | X | X | X | X | X | X | | | | |
| 23 65 00 | COOLING TOWERS | | X | X | | | X | X | X | | | |
| 23 63 13 | AIR COOLED CONDENSERS | | X | X | | X[1] | X | X | | | | |
| 23 57 00 | HEAT EXCHANGERS | | X | X | | | | | X | | | |
| 23 73 00 | PACKAGED INDOOR HVAC UNITS | | X | X | | | | | X | | | |
| 23 74 00 | PACKAGED ROOFTOP HVAC UNITS | | X | X | | X[1] | | X | X | | | |
| 23 81 23 | COMPUTER ROOM A/C UNITS | | X | X | | X[1] | | X | X | | | |
| 23 84 13 | HUMIDIFIERS | | X | X | | X[1] | | | | | | |
| 23 82 00 | TERMINAL UNITS | | X | X | | | | | | | | |
| 23 83 13 | ELECTRIC HEATING CABLES | | X | X | | | | | | | | |
| 23 34 00 | AIR HANDLING FANS | | X | X | | | | X | X | | | |
| 23 75 13 | AIR HANDLING UNITS | X | X | X | | | | X | X | | | |
| 23 41 00 | AIR CLEANING FILTERS | X | X | X | | | | | X | | | |
| 23 31 00 | DUCTWORK | X | X | X | X | X | X | | | | | |
| 23 31 13 | METAL DUCTWORK | X | X | X | X | X | | | | | | |
| 23 31 16 | NON-METAL DUCTWORK | X | X | X | X | X | X | | | | | |
| 23 31 19 | HVAC CASINGS | X | X | X | | | | | | | | |
| 23 33 00 | DUCT ACCESSORIES | | X | X | | X | | | X | | | |

| SPEC SECTION | ITEM | REQUIREMENTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SUBMITTALS | | | SUPPLEMENTAL | | FACTORY REP SUPER-VISION AT SITE | **TRAINING REQ=D AT SITE | **EXTRA MATERIAL | At completion of project obtain Owner's sign off that the following has been received: | | |
| | | Shop drawings | Product Data | Include in O & M | TEST | REPORT | | | | Training of Product | Extra Materials | Document |
| 23 33 19 | DUCTWORK SOUND ATTENUATION | | X | X | X | | | | | | | |
| 23 37 13 | AIR OUTLETS & INLETS | | X | X | | | | | X | | | |
| 23 36 00 | AIR TERMINALS | | X | X | | | | | | | | |
| 23 09 00 | CONTROLS AND INSTRUMENTATION | | X | X | X | X | | X | | | | |
| 23 09 23 | DIRECT DIGITAL CONTROL SYSTEMS | X | X | X | | X | X | X | | | | |
| 23 09 93 | SEQUENCE of OPERATION | | | X | | | | | | | | |
| 23 05 05 | REBUILDING OF EXISTING AIR HANDLING UNITS | | | X | | | | | | | | |
| 23 05 93 | TESTING, ADJUSTING AND BALANCING | | | X | | X | | | | | | |
| 23 08 00 | MECHANICAL COMMISSIONING | | | X | | X | | | | | | |

[1] Warranty - 5 year
[2] Warranty Report/Warranty
[3] Kitchen Exhaust Hood
[4] See Specific Specification Section for Test & Certification Requirements
[5] For Soft Starters
[6] Requires Review & Approval from T & B Contractor
**Requires Owner Sign Off

## 23 05 13 Common Motor Requirements for HVAC Equipment

- Provide all motors and starters for the project by a single manufacturer except when part of factory packaged equipment
- All variable frequency drives and soft start starters for the project shall be by a single manufacturer, including packaged equipment except chillers
- In the absence of other information, standards of the following organizations apply
  - NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors, and drives.
  - Applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces".
  - UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors" where applicable
  - UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.
  - Provide equipment and components which are UL-listed and labeled.
  - Provide equipment and components which are ETL-listed and labeled.
  - IEEE Compliance: Comply with applicable requirements of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters and Std 519.
  - Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies"
  - NEMA Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)", pertaining to motor controllers/starters and enclosures.
  - Standards
    - NEMA Standards MG 1: Motors and Generators
    - NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies
    - NEMA Standard 250: Enclosures for Electrical Equipment
    - NEMA Standard KS 1: Enclosed Switches
    - Comply with National Electrical Code (NFPA 70)
- Submittals
  - Coordinate with 23 05 00 Common Work Results for HVAC
  - Product Data
  - Shop Drawings
    - VFD’s and soft start starters
      - Physical dimensions of each unit

- General arrangements with incoming and outgoing conduit locations schematic
- Connection diagram sufficient to install system
- Enclosure details

- Wiring Diagrams
  - Power and control wiring diagrams, prepared for the project, of complete VFD and soft start starter assemblies
  - General wiring diagrams with various non-applicable options shown are not acceptable
  - Clearly differentiate between factory and field wiring
- Listing, Motors of Mechanical Work
  - Submit separate listing showing rating, power characteristics, efficiencies, power factors, application, and general location of every motor to be provided with mechanical work
    - Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.
  - Provide information for each field wired electrical power connection
    - Information shall use nameplate data and nomenclature of actual installed nameplates
    - Information should list as a minimum
      - Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase
      - Number and location of field connections
      - Field interconnection wiring
      - Operating voltage and phase
      - Maximum fuse size or maximum overcurrent protection size (as applies)
      - Minimum circuit ampacity
      - Full load amperes
      - Locked rotor current and duration for high inertia equipment
      - Manufacturers recommended overload setting (if applicable)

Motors

- Approved Manufacturers
  - Siemens/ITS
  - Sprecher+Schuh
  - Baldor

- Westinghouse
- General Electric
- Lincoln
- U.S. Motors
- Square D

- Torque characteristics be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer
- Capable of starting the driven equipment while operating at 90 percent rated terminal voltage
- Sizes large enough so that the driven load will not require the motor to operate in the service factor range
- 2-speed motors shall have (1) single winding on poly-phase motors.
- Explosion proof motors shall meet
  - Underwriters Laboratories Standards for use in hazardous locations
  - National Electrical Code (NEC), Article 500, Class and Group
- Rated for 40 degrees C environment with maximum 80 degrees C temperature rise for continuous duty at full load (Class B Insulation)
  - Provide Class F insulation for variable frequency drive motors.
- Frequency of starts as indicated by automatic control system and not less than 5 evenly time-spaced starts per hour for manually controlled motors
- Service Factor
  - 1.15 for poly-phase motors
  - 1.35 for single phase motors
  - 1.0 for inverter duty motors
- Motor construction
  - NEMA Standard MG 1, general purpose, continuous duty, Design "B", except
    - "C" where required for high starting torque
    - Design "E" is PROHIBITED
  - Frames
    - NEMA Standard No. 48 or 54
    - Use driven equipment manufacturer's standards to suit specific application
  - Bearings
    - Ball bearings with inner and outer shaft seals.

- Re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance.
- Bearings shall be rated for minimum L-10 life of 40,000 hours.
- Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
- For fractional horsepower, light duty motors, sleeve type bearings are permitted.

▪ Enclosure Type

- Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
- Guarded drip-proof motors where exposed to contact by employees or building occupants.
- Weather protected
  - Type I for housed outdoor use
  - TEPC II where not housed

▪ Overload protection

- Built-in thermal overload protection for all single-phase motors
- Internal sensing device suitable for signaling and stopping motor at starter as required

▪ Noise rating

- "Quiet"

▪ Minimum motor efficiencies shall conform to most recent ASHRAE Standard: “Minimum Nominal Efficiency for General Purpose Design A and Design B Motors”

▪ Nameplate: indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

o Phases and Current Characteristics

▪ Squirrel-cage induction polyphase motors for 3/4 hp and larger

▪ Capacitor-start single-phase motors for 1/2 hp and smaller, except

- 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type
- Tri-voltage motors are PROHIBITTED

o Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit

▪ These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.

- A factory load test shall be performed on each motor of 1000 watt input or greater to assure compliance energy-efficiency.
- All motors 75 HP and larger shall be factory test certified for power factor and efficiency and shall have a three-year warranty
  - Factory certification of motor tests shall be provided to LPS
- All equipment specified to operate with variable frequency drives shall be provided with inverter-duty motors specifically designed for variable speed operation with high efficiency at part load conditions and constructed with Class F inverter grade insulation
- All motors which will be operated by a variable frequency drive shall be warranted against any damage or defects as a result of being used with a variable frequency drive

Starters

- Approved Manufacturers
  - Siemens/ITE
  - Sprecher+Schuh
  - Cutler Hammer
  - Allen-Bradley
  - Square D
  - Eaton
- Provide 1 starter control for each pump
  - One (1) starter controlling multiple pumps is PROHIBITED
- Motor Starter Characteristics
  - NEMA 1, general purpose enclosures with padlock ears, except
    - Wet locations shall be NEMA 3R with conduit hubs
    - Units in hazardous locations which shall have NEC proper class and division
  - Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition
  - Two-speed starters with a High-Low selector switch wired to allow manual speed selection with the H-O-A in HAND or remote speed selection in AUTO
  - Automatic accelerating relay/timer to assure that the motor will always start at low speed and operate at an adjustable time before switching to high speed
  - Automatic decelerating timing relay to prevent damage to the motor and load when switching from high to low speed

- High and low speed contactors shall be mechanically and electrically interlocked
- Complete instructions for adjusting the timer in the field to match the deceleration characteristics of the driven equipment
- Cooling towers or other two-speed motors are required, as applicable, to have reversible operation, starters for those applications shall include the features described above for two-speed motors and include
  - Reverse Selector Switch wired to allow manual direction In the Hand position of the H-O-A
  - Starters with reverse direction shall have an integral built-in time delay to allow the motor to come to a full stop, prior to reversing for both the in the Hand and Automatic positions of the H-O-A switch
- Contacts shall open each ungrounded connection to the motor
  - Contacts shall be NEMA style, sized and rated, 75 degrees C.

o Manual switches
- Pilot lights and extra positions for multi-speed motors
- Overload protection: melting alloy type thermal overload relays

o Magnetic Starters
- NEMA style, sized and rated magnetic starters including contacts and coils for motors 3/4 hp and larger and for smaller motors where interlock or automatic operation is indicated or required
  - Maintained contact H-O-A push buttons and pilot lights, properly arranged for single speed or multi-speed operation
  - Solid state adjustable motor overload
    - Select range so that upper limit is no more than 150 percent of the connected motor full load amps
  - Interlocks, switches, and similar devices as required for coordination with control requirements of Division 23 Controls sections
  - Each starter shall be provided with (4) four additional spare sets of auxiliary contacts
    - Two (2) normally open
    - Two (2) normally closed
  - Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
  - Under-voltage release or protection, re-start of equipment shall be automatic unless required to be otherwise
    - Coordinate requirements with LPS OMC and LPS PM

- All 3-phase motors 2 hp and larger shall be protected against loss of phase (single phasing protection) wired into the starter
  - Reset shall be manual.
- Starters used for life safety systems
  - Additional control relay to by- pass all external safeties and internal safeties except for overload protection
  - Coordinate with Section 23 09 93

- Motor connections
  - Flexible conduit, except where plug-in electrical cords are specifically indicated

Soft-Start Starters

- Approved Manufacturers
  - Siemens/ITE
  - Sprecher+Schuh
  - Allen-Bradley
  - U.S. Electric
  - Square D
- Required for large equipment and/or for pumps in open loop piping system which may experience water hammer
  - Capable of controlling the starting inrush of a NEMA design B motor, and to reduce water hammer effects of the pumps when the motor is stopped.
- Engineer to review the following standards and coordinate with LPS OMC and LPS PM regarding updated technology or code requirements provided by the engineer
  - Main disconnect switch, a mechanical contactor, a six-SCR full wave bridge solid state reduced voltage starter, a thermal overload relay factory assembled in a single enclosure
  - NEMA 1 ventilated enclosure
  - Main AC line fused disconnect or circuit breaker mounted and wired, with a door interlock mechanism and padlocking means
  - Full NEMA style, HP sized and rated series contactor, including contacts and coils, ahead of the solid-state electronics
    - Contactor shall open on normal stop command, and if a shorted SCR is detected
  - Rated for a minimum of 350 percent current for 30 seconds.
  - Include adjustable thermal overload protection
  - Maintained contact H-O-A selector switch and red running pilot light

- Starter shall include an integral 120V control circuit transformer with primary and secondary fusing
- Starter shall be rated for full current operation at 40° C ambient temperature
- Interlocks, switches, and similar devices as required for coordination with control requirements
- Each soft start starter shall be provided with four (4) additional spare sets of auxiliary contacts
  - Two (2) normally open
  - Two (2) normally closed
- SCR's shall be rated 1600 PIV minimum
- Instantaneous overcurrent trip shall be included if current exceeds 900 percent FLA
- Metal Oxide Varistor (MOV) suppressors
- Heat sink over-temperature switch
- Shorted SCR detection and lockout
- Not start during a phase loss condition
- Diagnostics shall include LED indicators for
  - 3 phase power present
  - Shorted SCR detected
  - Motor overload
  - Instantaneous overcurrent
  - Starter ready
  - Starter on
  - Power supply failure
- Fault relay trip the series contactor in the event of
  - Motor thermal overload
  - Instantaneous overcurrent
  - Shorted SCR
- Adjustments include
  - Ramp time
  - Current limit
  - Jog voltage
  - Jog time
  - Deceleration time

- On starting, the starter shall be capable of applying an adjustable "jog" voltage to the motor for an adjustable time to magnetize the motor, then automatically switch to a controlled current ramp mode to accelerate the load.
- On stopping, the starter shall include an "anti-water hammer" circuit which is capable of accepting a 0-10V DC signal proportional to flow from the building automation system and controlling the voltage to the motor to obtain a smooth reduction in flow without excessive pipe movement or water hammer
  - As a backup, a linear voltage ramp deceleration mode shall be available
- Authorized factory trained service personnel to do on-site start-up and adjustment for each soft start starter

Disconnect Switches

- Per Division 26 requirements

Drives

- Approved Manufacturers
  - Siemens/ITE
  - Sprecher+Schuh
  - Allen-Bradley
  - U.S. Electric
  - Square D
- V-Belt Drives:
  - Capacity of V-Belt Drives at rated RPM shall be not less than 150 percent of motor nameplate horsepower rating
  - V-Belt Drive combinations shall be limited to A, B, C, and fractional horsepower belts
    - 3V, 5V and 8V belts and sheaves are PROHIBITED
  - Motors and Fan Wheel Pulleys
    - :Adjustable pitch for use with motors through 15 HP
    - Fixed pitch for use with motors larger than 15 HP
    - Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions
  - All fixed pitch sheaves, including single groove fan sheaves, shall be of the bushed type
    - Fixed bore sheaves are PROHIBITED for adjustable pitch sheaves.
  - Belts: Oil-resistant, nonsparking, and nonstatic

- Unit manufacturer shall provide OSHA approved belt guard with tachometer holes
- Equipment serving hazardous or critical systems (i.e., fume hoods, biohazards, life safety, etc.)
  - All fans shall be provided with 1.5 times the number of belts normally required to meet above requirements
  - Minimum of 2 belts required

Variable Frequency Drives

- Approved Manufacturers
  - ABB
  - Square D
  - Eaton
  - Aquavar
  - Yaskawa
- Verify relief air by pass requirements for AHU's with VFDs and By-pass Starter
- Locate VFD as close as possible to motor to reduce possible motor damage or increased wiring size.
- Provide 1 VFD control for each pump
  - One (1) VFD controlling multiple pumps is PROHIBITED
- Comply with NEMA and IEEE Standards as applicable to wiring methods, construction and installation and operation of VFDs
- Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing
  - The entire unit to carry the label, not just components
- Factory tests on VFD assembly as a complete package (not just individual components)
  - High pot test per UL
  - Test assembled panel with a motor load
  - Test operation of all components and pilot lights
- Enclosure
  - Mount VFD and all components within a NEMA 1 metal enclosure for normal indoor conditions
    - Meet manufacturer requirements for
      - Wet, dusty, outdoor, etc., locations
      - Filters for moderately dirty

- By-pass components shall be in a separate compartment or enclosure as noted below
- Provide floor stand where building walls are not suitable for mounting drive
- Provide filtered, fan powered ventilation for drive cooling
  - Fan sized for “dirty filter” condition at project altitude
- Drive and by-pass enclosure doors shall have provisions for locking with a padlock or integral lock, keyed to the building standards.
- Switches and pilot lights shall be labeled with engraved plastic laminate tags riveted or similarly permanently fastened.

o By-pass and Disconnects

- Manual by-pass circuitry in a separate compartment
- Door fused disconnect with Type “J” fuses, with a through-the-door handle, pad lockable in the OFF position
  - The door interlock shall be defeatable with a tool to allow service access without de-energizing the system
  - The disconnect shall remove power from all components within both compartments
- Three position “VFD/OFF/BY-PASS” switch to control VFD line side, VFD load side, and by-pass contactors
  - Contactors shall be interlocked to completely isolate the VFD in the by-pass mode for service
- Control relays to operate by-pass contactor due to remote start/stop, safety interlock, or via the HAND-OFF-AUTO switch
  - See “Controls and Operation” below
- Three pole motor overload relay connected to shut down the motor in both the VFD and by-pass modes
- 120V control power transformer with fused secondary and primary
  - Primary power shall be derived ahead of the VFD input contactor
- Panel shall be arranged to allow power-off maintenance of the VFD while motor is operating on by-pass
  - By-pass or control circuitry in the same compartment as the VFD is PROHIBITED

o Input Power

- The drive shall be capable of accepting facility power as required
  - Variations of up to plus or minus 10 percent of line voltage and plus or minus 2HZ of line frequency shall be permitted without the drive shutting down on a fault

- Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault
- The drive input circuitry shall not generate line notches or large voltage transients on the incoming line
- The drive efficiency at rated load and frequency shall be 95 percent or better
- The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load
- Manufacturer guarantee that harmonic voltage and current distortion, on the line side (input terminals) of the VFD does not exceed 5 percent total voltage Harmonic distortion, and 15 percent total current Harmonic distortion

o Output Power

- The variable frequency AC drive shall convert 3 phase, 60 HZ input power to an adjustable AC frequency and voltage for controlling the speed of any standard NEMA B Design, AC squirrel cage motors driving variable torque loads
  - The drive rated for continuous duty at the NEC standard full load current of its associated motor
- Transistors (IGBT) to produce a sine weighted PWM three phase output for the load
- The drive shall have sufficient capacity to provide stepless speed control of the motor throughout the operating range as specified herein
- The drive output will be adjustable from 0 to 60 HZ
- The drive shall have the capability to adjust the frequency above 4 kHz. The drive shall not operate with a frequency above 12 kHz
- The IGBTs shall have a minimum rating of 1200 VDC on 480 V units and 600 VDC on 230 V units
- The drive shall be suitable for operating at the altitude of the project location with no degradation or loss of performance

o Control and Operation

- Adjustable acceleration and deceleration, with automatic acceleration rate limiting to avoid overload and automatic deceleration rate limiting to avoid excessive regeneration voltage
- Speed/frequency settings to limit the maximum and minimum motor speed, to avoid up to three (3) system critical resonance points and to provide a preset speed for operation in the event of loss of the remote speed signal
- Capability to set drive to a pre-determined speed upon contact closure input from the BAS

- Capability of restarting into a rotating motor
- The following operator control and monitoring functions shall be accessible without opening the door of the enclosure
  - HAND/OFF/AUTO (or Local/Off/Remote) selector switch
    - With the “H-O-A” switch in the “HAND” or “LOCAL” position, the motor shall start in either VFD or by-pass mode as determined by VFD/OFF/BYPASS switch, and if in the “VFD” mode, the speed shall be controlled by the manual speed adjustment on the drive door
    - With the “H-O-A” switch in “AUTOMATIC” or “REMOTE”, the motor shall start from the remote start/stop input in either VFD or by-pass mode as determined by the VFD/OFF/BYPASS switch and, if in the “VFD” mode, its speed shall be controlled by the BAS input speed signal
    - With the “H-O-A” switch in the “OFF” position, the run circuit will be open, and the VSC will not operate
    - This must be a physical switch, not a keypad input function
  - Manual (local) speed adjustment
  - Frequency (speed) indication
  - Output amperage indication
  - Pilot lights
    - Power On (green)
    - VFD Fault (red)
    - External Fault (red)
    - Motor on VFD (green)
    - Motor on By-pass (red)
    - Motor Overload (red)
- Control Interfaces
  - Coordinate with points list and Section 23 09 93 Sequence of Operations
  - Remote start/stop (run enable input)
    - Provide a control relay and a terminal block in the by-pass compartment to allow remote start/stop in either the VFD or by-pass mode.
  - Remote speed input signal
    - 4-20 mA, 0-5 VDC, 0-10 VDC, or as required by control system
    - Coordinate with Section 23 09 23

- Safeties interlock input
  - Provide a control relay and terminal block in the by-pass compartment to allow hardwired safety shutdown in either the VFD or by-pass mode
- Fault indication output contacts. Indicate fault for the following:
  - Drive protection features
  - Safety interlock
  - Drive hardware fault
  - Input power fault
  - Others as provided by manufacturer
- Speed indication output (isolated)
- Amperage indication output
- Run forward input
- Run backward input
- Drive running (status) output
- Drive on by-pass output
- Drive on manual output
- Pre-set speed input
- RS 485 communications to DDC system
- Complete open protocol communications with DDC system

▪ Provide a key pad and scrolling LCD display for operator interface with programming capabilities, fault diagnostics, fault reset, and security lockout code
- Information shall be presented in plain English, not requiring codes
- Key pad shall not be accessible without opening enclosure panel door

▪ Each variable frequency drive to be provided with four (4) additional spare sets of auxiliary contacts
- Two (2) two normally open
- Two (2) normally closed

o Drive Protection and Safety Features
▪ Ground fault protection
▪ Electronic motor overload protection
▪ Over-voltage/under-voltage protection

- Automatic restart after a trip condition resulting from over-voltage or under-voltage
- Manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts

▪ Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements

▪ Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses

▪ Input phase loss and undervoltage protection

▪ Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload or slow the acceleration ramp when accelerating a high inertia load

▪ High/over temperature protection

▪ "Bus Charged" warning indicator, and automatic circuitry to discharge the bus within 120 seconds after main power is disconnected

o VFDs serving multiple motors

▪ Provide automatic transfer for each motor where primary/standby equipment operation sequence is specified in Temperature Controls Section, Sequence of Operation

▪ Provide motor contactors for each motor for drives serving more than one motor, each contactor shall have auxiliary contacts to prevent drive damage if remote motor disconnect switch is open or closed

- Temperature control contractor to provide all field wiring to each motor contactor to initiate the drive to automatically transfer load from one motor to another motor as selected by the temperature control system
- All automatic transfer equipment and time delays to be a part of the variable frequency drive equipment and enclosed within the drive cabinet

▪ Each drive shall have contactors for each motor(s) it serves with individual thermal overload protection for each motor.

▪ All multiple motor variable frequency drives shall be capable of operating even if one of the motors is off.

▪ Speed pots to be located inside of cabinet

o Drive manufacturers using portable test meter for diagnostics

▪ Provide not less than one test meter for every five (5) variable frequency drives for each model or type used

▪ Meters supplied to LPS at project completion

- Each drive shall include an RS 232 port with 25 pin "D" connector to allow downloading of parameter settings and fault history logs to a standard IBM compatible portable computer or printer
  - Include software to allow downloads
- The audible dBA sound level of the complete system (motor & VFD) when operated over the full speed range shall be not more than 10 percent above the sound level of the motor operated in the by-pass mode (60 hZ building power)
  - Test is REQUIRED to be performed during initial startup
- 36-month warranty after the building has been accepted by the Owner
  - Warranty shall include all parts, labor, materials, shipping cost, travel, lodging, and meals with no cost to LPS
- General Installation
  - Provide 4-inch-high concrete housekeeping pad for floor mounted variable frequency drive
  - Where a separate disconnect switch is provided in the motor feeders between a VFD and the motor, provide an end switch at the disconnect to open the remote interlock shutdown circuit power circuit
- Start-Up and Testing
  - VFD Start-Up
    - Provide field start-up service by an authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up services shall include system check-out, start-up and system run.
    - Start-up adjustments shall include optimizing frequency, optimizing volts/Hz ratio, identifying, and avoiding resonant speeds, setting accel/decel ramps, and setting overload and circuit breaker trip points.
  - VFD Harmonic Distortion Testing
    - Test and report REQUIRED upon completion
    - Conducted by an approved independent testing agency.
      - Measure the harmonic voltage and current distortion of each VFD with the drive assembly in by-pass mode, with the VFD running at 50 percent operating speed and with the VFD running at highest operating speed.
      - Take measurements on each phase (L-L) on the line side (input terminals) of the VFD
    - Install corrective reactors or filters at no additional cost to the owner and retake measurements after corrective equipment is installed.

- Include all measurements (before and after) in the harmonic distortion report
- Provide engineer with a copy of the harmonic distortion report

- VFD Noise Test
  - Measure the dBA sound level of the motor with the drive-in by-pass mode, and with the drive operating at 25 percent, 75 percent, and 100 percent speed output
  - Correct as required at no cost to LPS and retake measurements
  - Report all tests to the engineer, LPS OMC and LPS PM
- VFD Induced Shaft Voltage Test
  - After installation is complete, and system is operating under normal conditions
    - Between substantial completion and the end of the overall project warranty period
  - Measure and report any voltage potential between the motor shaft and the motor frame
  - Correct as required at no cost to LPS and retake measurements
  - Report findings to engineer, LPS OMC and LPS PM

## 23 05 16 Expansion Fittings and Loops for HVAC Piping

- In the absence of any other information, work shall be provided in accordance with standards of
  - Expansion Joint Manufacturer's Association (EJMA)
- Submittals
  - Product Data
    - Installation instructions for each type of expansion compensation product
    - Expansion compensation schedule showing Manufacturer's figure number, size, location, and features for each required expansion compensation product.
  - Shop Drawings
    - Assembly-type shop drawings for each type of expansion compensation product, indicating dimensions, weights, required clearances, and methods of assembly of components.
    - Shop drawings for fabricated expansion loops indicating location, dimensions, pipe sizes, and location and method of attachment of anchors.
  - Maintenance Data
    - Maintenance data and spare parts lists for each type of expansion compensation product
  - Closeout
    - Submittals listed above updated to record status
- Pipe expansion joints shall provide 200 percent absorption capacity of calculated piping expansion between anchors

Packless Expansion Joints

- Approved Manufacturers
  - Flexonics Div.; UOP, Inc.
  - Garlock
  - Hyspan Precision Products, Inc.
  - Thermo-Tech
  - Mason Industries, Inc.
  - Metraflex Co.
- Packless Rubber Expansion Joints
  - Fabric-reinforced butyl rubber with full- faced integral flanges
  - External control rods

- Internally reinforced with steel retaining rings over entire surface of flanges
- Drilled to match flange bolt holes

o Bellows-Type Expansion Joints

- As required
- Materials and pressure/temperature ratings selected by manufacturer to suit intended service
- Provide 200 percent absorption capacity with 30 percent safety factor
- ASTM A240 T304 Stainless Steel laminated bellows
- Flanged Connections, conforming to ANSI B16.5
- 150 psig design pressure
- Minimal warranted cycle life of 10,000 full-stroke cycles
- Externally pressurized, bellows-type
  - Lifting lug
  - Drain port
  - Internally guided
- Bellows-type expansion joint
  - Internal stainless-steel liner
  - Shouldered support of bellows to minimize stress at pipe-bellows weld.
  - External shroud

Packless Expansion Joints Compensators

o Approved Manufacturers

- Flexonics Div.; UOP, Inc.
- Garlock
- Hyspan Precision Products, Inc.
- Thermo-Tech
- Keflex, Inc.
- Metraflex Co.
- American BOA, Inc.

o Pressure rated

- 125 psi for low-pressure systems
- 175 psi for high-pressure systems

o Cycle life of 10,000 full-stroke cycles

- Copper piping systems
  - 2-ply phosphor bronze bellows, brass shrouds, and end fittings
- Steel piping systems
  - 2-ply stainless steel bellows, carbon steel shrouds, and end fittings
- Internal guides and anti-torque device and removable end clip for proper positioning

Pipe Alignment Guides

- Approved Manufacturers
  - Hyspan Precision Products, Inc.
  - Metraflex Co.
  - Keflex, Inc.
- Pipe alignment guides at locations and spacing as required
  - Piping that adjoins expansion joints and elsewhere
  - Anchor to building substrate
- 4- finger spider traveling inside guiding sleeve
- Provision for anchoring to concrete substrate
- Factory insulation insert
  - Thickness to match adjoining insulation
  - Hydrous Calcium Silicate insulation
  - 1200° F maximum temperature
  - 0.31 K-factor
  - Vapor barrier

Slip Joints

- Approved Manufacturers
  - Hyspan Precision Products, Inc.
  - Advanced Thermal Systems, Inc
- Carbon steel slip type
- Designed for repacking under pressure
- Asbestos-free packing compound

Flexible Ball Pipe Joints

- Approved Manufacturers
  - Advanced Thermal Systems, Inc.
  - Barco Div., Marison Industries
  - Gustin-Bacon Div.; Aeroquip Corp.
- 360-degree rotation

- Angular Deflection
  - Minimum of 30 degree for sizes 6 inches and smaller
  - Minimum of 15 degree for sizes 8 inches and larger
- Carbon steel and shall comply with Section II of ASME Boiler and Pressure Vessel Code and ASME B31.9 "Building Service Piping" for materials and design of pressure containing parts and bolting
- Asbestos-free packing
  - Factory tested with steam at working pressure of piping system for zero leaks

Grooved Piping Couplings and Nipples Expansion Joints

- Approved Manufacturers
  - Victaulic Co. of America
  - ITT Grinnell
  - Gustin-Bacon Div.; Aeroquip Corp.
- Suitable gasket material for piping system as required
- Combination Couplings and Nipples
  - Cut grooved short ASTM A 53 steel pipe nipples and ductile iron or malleable iron couplings
  - Removable ties to hold joint compressed or expanded during piping fabrication
- Slip-Type Expansion Joints
  - Ductile iron or malleable iron housing, ASTM A 53 steel pipe body
  - Polytetrafluoroethylene (PTFE) modified polyphenylene coated steel pipe slide

- Expansion Joints
  - As required for adequate expansion of installed piping system
  - Align units properly to avoid end loading and torsional stress
- Expansion Loops:
  - Fabricate to dimensions and in locations as required for adequate expansion compensation of installed piping system
  - Pipe anchors and pipe alignment guides to properly anchor and align piping in relationship to expansion loops
- Expansion Compensation for Risers and Terminals
  - Provide details on drawings
  - Install connection between piping mains and risers with at least
    - 5 pipe fittings including tee in main
    - 4 pipe fittings including tee in riser

## 23 05 19 Meters and Gauges for HVAC Piping

- In the absence of any other information, work shall be provided in accordance with
  - UL standards pertaining to meters and gauges
  - Applicable portions of ANSI
  - Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges
- Submittals
  - Product Data
    - Installation instructions for each type of meter and gauge
    - Include scale range, ratings, and calibrated performance curves, certified where indicated
    - Meter and gauge schedule showing manufacturer's figure number, scale range, location and accessories for each meter and gauge
    - All flow measuring devices to be provided shall be reviewed and approved by the test & balance contractor and the temperature control contractor for proper scale, rangeability and function prior to submitting shop drawings
    - The test & balance contractor and temperature control contractor shall provide a typed letter stating this review has been completed and is included with shop drawing submittals
  - Maintenance Data
    - Maintenance data and spare parts lists for each type of meter and gauge
  - Closeout
    - Submittals listed above updated to record status

Temperature Gauges and Fittings

- Glass Thermometers
  - Approved Manufacturers
    - Ashcroft
    - Duro
    - Marshalltown Instruments, Inc.
    - Tel-Tru
    - Trerice (H.O.) Co.
    - Weiss Instruments, Inc.
    - Weksler

- Ernst Gauge Co.

- Case: Die-cast aluminum-finished in baked epoxy enamel, glass front, spring secured, 9 in. long
- Adjustable Joint: Die cast aluminum, finished to match case, 180 degrees adjustment in vertical plane, 360 degrees adjustment in horizontal plane, with locking device
- Tube and Capillary: Mercury filled, magnifying lens, 1 percent scale range accuracy, shock mounted
- Scale: Satin faced, non-reflective aluminum, permanently etched markings
- Stem: Copper-plated steel, or brass, for separable socket, length to suit installation. Sampling tube type with duct flange for air duct installations
- Range
  - Hot Water
    - 30 degrees - 240 degrees F
      - 2 degrees F scale divisions
    - 0 degrees - 160 degrees C
      - 2 degrees C scale divisions
  - Chilled Water
    - 0 - 100 degrees F
      - 2 degrees F scale divisions
    - 0 degrees - 100 degrees C
      - 1 degrees C scale divisions
  - Duct work
    - 0 - 160 degrees F
      - 2 degrees scale divisions

o Remote Reading Dial Thermometers

- Approved Manufacturers
  - Ashcroft
  - Duro
  - Marshalltown Instruments, Inc.
  - Tel-Tru
  - Trerice (H.O.) Co.
  - Weiss Instruments, Inc.
  - Weksler

- Ametek/U.S. Gauge.
- Marsh Instrument Co.; Unit of General Signal.
- Versa Gauge

▪ Vapor tension
▪ Drawn steel or brass, glass lens, 4-1/2-inch diameter
▪ Movement: Brass, precision geared
▪ Tubing: Bronze double braided armor over copper capillary, length to suit installation
▪ Bulb: Copper with separable socket for liquids, averaging element for air
▪ Accuracy: + or - one scale division
▪ Range

- Hot Water
  - 30 degree - 240-degree F (0 degree - 115 degree C)
- Chilled Water
  - 30 degree - 180-degree F (0 degree - 85 degree C)
- Air
  - 30 degree - 180-degree F (0 degree - 85 degree C)

o Photo Voltaic Digital Thermometers

▪ Approved Manufacturers

- Weiss Instruments
- Versa Gauge

▪ Case: High image ABS, with photovoltaic power cell and digital readout
▪ Range: Selectable between -40-300 degrees F/ -40-150 degrees F, displayed to 0.1 degrees
▪ Accuracy: 1 percent of reading or 1 degrees F, whichever is greater

- Re-calibratable via internal potentiometer
- Not affected by ambient temperature

▪ Ambient light required: 10 lux
▪ Display update: 10 seconds
▪ Stem: Compatibly with standard thermowell for piping applications, or sampling tube with flange for air duct applications

o Dial Type Insertion Thermometers and Wells

▪ Approved Manufacturers

- Trerice (H.O.) Co.

- Weiss Instruments, Inc.
- Marsh Instrument Co.; Unit of General Signal.
- Taylor Instrument Co.

▪ Type: Bi-metal, stainless steel case and stem, 1-inch diameter dial, dust and leak proof, 1/8 inch diameter stem with nominal length of 5 inch

▪ Accuracy: 0.5 percent of dial range

▪ Range

- Hot Water
  - 0 degrees - 220 degrees F (-10 degrees - 110 degrees C)
- Chilled Water
  - 25 degrees - 125 degrees (-10 degrees - 110 degrees C)

o Temperature Gauge Connector Plugs

▪ Approved Manufacturers

- Fairfax Company
- Peterson Equipment Co.
- Universal Lancaster
- Sisco
- MG Piping Products Co.

▪ Pressure rated for 500 psi and 200 degrees F (93 degrees C)

▪ Construct of brass and finish in nickel-plate, equip with 1/2inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch

▪ O.D. probe assembly from dial type insertion thermometer

- Equip orifice with gasketed screw cap and chain
- For insulated piping provide extension, length equal to insulation thickness

o Thermometer Wells

▪ Constructed of brass or stainless steel

▪ Pressure rated to match piping system design pressure

▪ 2-inch extension for insulated piping

▪ Cap nut with chain fastened permanently to thermometer well

Pressure Gauges and Fittings

o Pressure Gauges

▪ Approved Manufacturers

- Ashcroft
- Duro
- Ametek/U.S. Gauge.
- Marshalltown Instruments, Inc.
- Trerice (H.O.) Co.
- Weiss Instruments, Inc.
- Marsh Instrument Co.; Unit of General Signal.
- MG Piping Products Co.
- Versa Gauge

▪ General use, 1 percent accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection

▪ Drawn steel or brass, glass lens, 4-1/2inch diameter.

▪ Brass connector with 1/4inch male NPT

▪ Scale: White coated aluminum, with permanently etched markings.

▪ Range

- Vacuum
  - 30 inches Hg - 15 psi
- Water
  - 0 - 100 psi

o Pressure Gauge Connector Plugs

▪ Approved Manufacturers

- Fairfax Company
- Peterson Equipment Co.
- Universal Lancaster
- Sisco
- MG Piping Products Co.

o Pressure Gauge Cocks

▪ Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems

- Gauge cock shall be ¼ inch female NPT on each end ball valve as specified in Section 23 05 23 - Valves.

▪ Syphon: ¼ inch straight coil constructed of brass tubing with ¼ inch male NPT on each end

- Snubber: ¼ inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating

Flow Measuring Meters

- Venturi Tube Flow Measuring Elements
  - Approved Manufacturers
    - Flow-set
    - Gerand
    - Presco
    - Dieterich Standard Corp.
    - Barco/Aeroquip Corp.
    - Flow Design Inc.
  - Primary flow measuring elements shall consist of Venturi tubes
    - In horizontal pipes, place connections slightly above horizontal centerline of pipe
  - Provide each primary element with integral tab, or metal tag on stainless steel wire, extending outside pipe covering on which is stamped or clearly printed in plainly visible position the following information
    - Manufacturer's name and address.
    - Serial number of meter to which element is to be connected
    - Name, number, or location of equipment served
    - Specified rate of flow
    - Multiplier (including unity, where applicable) to be applied to meter reading
  - Provide taps with Schraeder or Hanson type fittings
    - Provide tap extensions to accommodate insulation
  - Manufacturer shall certify Venturi tubes for actual piping configuration
    - Any necessary piping changes required for certification shall be provided without cost to Owner
    - Insert type tubes may be furnished, provided they meet specification requirements in other respects
  - Provide Venturi with throat diameter such that specified rate of flow will register scale reading of between 20 percent and 80 percent of full-scale value

- Venturi sizes and beta ratios shall be selected so that design flow rates shall read between 20 percent and the full scale range on a linear meter (e.g. between 10inches and 50 inches on a 0- 50 inches meter), with permanent pressure loss of not more than 25 percent of indicated flow rate differential pressure
- Provide Venturi tubes of solid brass or bronze
  - Tubes larger than 2 inches shall have flanges or butt weld connections and may be cast iron or steel
  - Steel tubes may be fabricated or cast with cadmium or zinc-plating. Line throats of cast iron tubes with bronze, and plate cast iron portion with cadmium
- Tubes shall be calibrated and tested by independent testing laboratory and performance data furnished with shop drawings.
- Connections for attachment to portable flow meter hoses shall be readily accessible.

o Calibrated Balancing Valves

- Approved Manufacturers
  - Armstrong+
  - "Flowset" - Flow Design, Inc.
  - Presco.
  - Tour and Anderson, Inc.
  - Gerand "Balvalve Indicator"
  - Bell and Gossett (To Match Existing Only)
- Match existing balance valves whenever possible
- Equipped with readout valves to facilitate connecting of differential pressure meter to balance valves
  - Equip each readout port with a quick connect valve designed to minimize system fluid loss during monitoring process
  - Provide balance valves with preformed insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment
- Variable orifice type
  - Globe-type valve
  - Multiple turns of handwheel from full closed to full open
  - Bubble-tight shut-off
  - Schraeder type taps upstream and downstream

- Memory stop device to allow valve to be returned to balanced position after being closed
- Provide slide rule type flow calculator, include in Operation and Maintenance Manual

▪ Valve and Venturi type

- Ball or butterfly type valve
- Bubble-tight shut-off
- Fixed Venturi, upstream of valve
- Schraeder type taps on Venturi, upstream and downstream
- Memory stop device to allow valve to be returned to balanced position after being closed
- Provide metal tag with flow curve for each valve

o Flow Meter Read-out Kits

▪ With bellows type differential pressure element and minimum 5-inch diameter indicating dial

▪ Design pressure elements for full scale pressure differential of 50 inches or 100 inches water gauge

- Design shall incorporate rupture-proof metal beryllium or stainless-steel bellows and torque tube drive requiring no lubrication
- Design forged bodies for not less than 150 percent of maximum surge pressure, fully protected against surges, with full provision for venting and draining
- Provide integral, adjustable pulsation dampers

▪ Dials of portable meters shall have square root scales not less than 12 inches in developed length

- Dials shall read from 0 to 10 gpm to which multiplier is to be applied, as required
- Uniform scale reading from 0inches to 10 inches w.g., to which multiplier of 10 to be applied (100 inches at full scale), or from 0 inches to 5 inches w.g., to which multiplier of 10 is to be applied (50 inches at full scale)

▪ Engineer and manufacture in accordance with ASME recommendations for flowmeters

▪ Provide portable meters with overall accuracy of + 5 percent.

▪ Provide flow meter with factory-fabricated carrying case with integral carrying handle

- Case shall be fitted to hold meter and following accessories

- Two 10 feet lengths of connecting hose with suitable female connectors for connecting to Venturi tube pressure tap nipples
  - Design hose for operating pressure of minimum of 150 percent of maximum system operating pressure
- Completely assembled 3-value manifold with 2 block valves and vent and drain valves shall be piped and mounted on base, which shall be designed for use lying flat on stationary base
- Bound set of descriptive bulletins, installation and operating instructions, parts list, and set of curves showing flow verses pressure differential for each orifice or Venturi tube with which meter is to be used
- Metal instruction plate, secured inside cover, illustrating use of meter
- Deliver meter with case to LPS OMC and signed as accepted transmittal to LPS PM

- General Installation
  - Located in accessible locations at most readable position
  - Thermometers
    - Install thermometers in vertical upright position, and tilted to be easily read by observer standing on floor
    - Coordinate glass thermometer locations with LPS OMC
    - Use photovoltaic thermometers in mechanical spaces with ADEQUATE lighting levels
    - Coordinate locations with details in the following locations, and elsewhere as required
      - At inlet and outlet of each
        - Hydronic zone
        - Hydronic boiler and chiller.
        - Hydronic coil in air handling units, and built-up central systems
        - Hydronic heat exchanger
        - Hydronic heat recovery unit
        - Thermal storage tank.
      - In discharge duct or plenum of air handling units and built-up central systems
    - Remote Reading Dial Thermometers
      - Show remote thermometers on plans or specify locations. Where needed, this function is typically met by digital readouts from the BAS on buildings with DDC.

- Thermometer Wells
  - Vertical upright position
  - Fill well with oil or graphite, secure cap.
- Temperature Gauge Connector Plugs
  - Secure cap
  - Provide portable temperature gauge for each plug connection.

o Pressure Gauges

- Coordinate locations with details in the following locations, and elsewhere as required
  - At suction and discharge of each pump
  - At discharge of each pressure reducing valve
  - At water service outlet
  - At inlet and outlet of water-cooled condensers and refrigerant cooled chillers
- Pressure Gauge Cocks
  - Install in piping tee with snubber
- Pressure Gauge Connector Plugs
  - Secure cap
  - Provide portable pressure gauge for each plug connection

o Flow Measuring Meters

- Install in the following locations, and elsewhere as required
  - At discharge of each pump
  - At inlet of each hydronic coil
- Wafer-Type Flow Meters
  - Install between 2 Class 125 pipe flanges, ANSI B16.1 (cast-iron) or ANSI B16.24 (cast- bronze)
- Calibrated Balance Valves
  - Readout valves in vertical upright position
  - Maintain minimum length of straight unrestricted piping equivalent to 3 pipe diameters upstream of valve

## 23 05 23 General-Duty Valves for HVAC Piping

- Valves shall be accessible (within or immediately adjacent to equipment housings) and be able to isolate zones (supply and return)
- In the absence of any other information, work shall be provided in accordance with
  - MSS Standard Practices
    - Bypass and Drain Connection Standard
    - Butterfly Valves
    - Cast Iron Swing Check Valves, Flanged and Threaded Ends
    - Ball Valves with Flanged or Butt-Welding Ends for General Service
    - Cast Iron Plug Valves, Flanged and Threaded Ends
    - Steel Valves - Socket Welding and Threaded Ends
    - Cast Iron Globe and Angle Valves, Flanged and Threaded Ends
    - Valve User Guide
  - Solenoid valves shall be
    - UL listed
    - FM / AGA / ANSI and CSA approved
- Submittals
  - Product Data
    - Body material
    - Valve design
    - Pressure and temperature classification
    - End connection details
    - Seating materials
    - Trim material and arrangement
    - Dimensions and required clearances
    - Installation instructions
  - Closeout
    - Submittals listed above updated to record status
- Valve Features
  - Valves shall have rising stem or rising stem outside screw and yoke design; except non-rising stem valves may be used where headroom prevents full operation of rising stem valves
  - Operators
    - Handwheels, fastened to valve stem for valves other than quarter turn

        - Lever Handle on quarter turn valves 6 inch and smaller, except plug valves
            - Provide a wrench for every plug valve
        - Chainwheel operators for valves 2-1/2 inch and larger that are installed 96 inches or higher above finished floor elevation
            - Provide chains to an elevation of 6'-0" above finished floor elevation.
        - Worm gear operators of an enclosed weather-proof design shall be provided on all quarter turn valves 8 inches and larger
    - Where insulation is indicated or specified, provide extended stems to allow full operation of the valve without interference by the insulation
- Ball Valves
    - Approved Manufacturers
        - Conbraco (Apollo)
        - Crane
        - Nibco
        - Milwaukee
        - Watts
        - Jomar
    - 2-piece is acceptable
        - Use 3-piece for brazed lines and other areas required or requested by LPS OMC
    - Ball Valves 1inch and Smaller
        - 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F
        - Two piece end entry body style, bronze body conforming to ASTM B584
        - Full port chrome plated brass ball
        - 15 percent glass reinforced PTFE seats, PTFE packing, adjustable packing nut blow- out proof stem
        - Vinyl covered steel handle
        - Solder or threaded ends to match piping system
    - Ball Valves 1-1/4 inch through 2 inches and for all silver soldered or brazed lines
        - ANSI B16.34, 150 WSP, 600 WOG, rated for 150 PSI at 350 degrees F
        - Three piece body style, bronze body conforming to ASTM B584
        - Full port, chrome plated brass ball and stem of ASTM A276 type 316

        - 15 percent glass reinforced RTFE seats, RTFE packing and blow out proof stem
        - Vinyl coated steel handle
        - Solder or threaded ends to match piping system
    - Ball valve options/accessories
        - Tee handle for tight fit applications (within enclosures, etc.)
        - Locking handle
        - Drain
        - Stem extension
        - Mounting pads
- Eccentric Plug Valves
    - PROHIBITED for use in LPS hydronic systems
- Globe Valves
    - Approved Manufacturers
        - Crane
        - Jenkins
        - Luckenheimer
        - Walworth
        - Stockham
        - Grinnell Corp.
        - Hammond
        - Nibco
        - Milwaukee
    - Plumbing Systems (2-1/2 inches and Smaller)
        - Copper-silicon bronze stem
        - Non-asbestos Teflon-impregnated stem packing
        - Malleable iron handle
        - MSS SP-80, Class 125 WSP body, bonnet, and disc cast bronze ASTM B62
            - Bronze disc ring
            - Threaded bonnet
        - MSS SP-80 Class 150, body, bonnet and bonnet ring, cast bronze ASTM B-62
            - Teflon disc
            - Union bonnet

- Butterfly Valves
  - Approved Manufacturers
    - Crane
    - Keystone/Tyco
    - Nibco
    - Centerline
    - K.F. Hale
    - Bray
  - Extreme pressures and/or temperatures or sizes over 12 inches require special engineering.
  - Hydronic Service Butterfly Valves - 2-1/2 inches to 12 inches
    - MSS SP-67, cast iron body conforming to ASTM A126 class B
    - Aluminum bronze ASTM B148 disc
    - Single piece 416 stainless steel stem
    - EPDM seat
    - Upper and lower bronze bearing, non-metallic bushing and stem seal
    - ANSI class 125 flange, rated for 200 psi pressure differential
    - 200 psi drop-tight shut off dead end service, with downstream flange removed
    - Extended neck for 2 inches thick insulation
    - All valves shall be factory tested to 110 percent of pressure rating
    - All butterfly valves shall be full lugged body, drilled and tapped
- Swing Check Valves
  - Approved Manufacturers
    - Crane
    - Jenkins
    - Luckenheimer
    - Walworth
    - Conbraco
    - Grinnell Corp.
    - Nibco
    - Watts (screwed)
    - Stockham
    - Grinnell (Grooved Only)

- Swing Check Valves – 2 1/2 Inch and Smaller
  - MSS SP-80; Class 125/150 WSP 200/300, cast bronze body and cap conforming to ASTM B 62, ASTM B61 for 200/300 bronze
  - Horizontal swing design, Y-pattern, with a bronze/Teflon disc, stainless steel pin and having threaded or solder ends
  - Class 150 valves meeting the above specifications may be used where pressure requires or if Class 125 valves are not available
- Swing Check Valves – 2 1/2 to 3 Inch
  - MSS SP-71; Class 125 /250 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126 Class B
  - Horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends
  - Valve shall be capable of being refitted while the valve remains in the line
  - For sewage ejector and sump pump discharge swing check valves 2-1/2 inches and larger
    - Provide outside lever with weight or spring to assist disc to close rapidly

- Non-Slam Check Valves
  - Approved Manufacturers
    - Crane
    - Jenkins
    - Luckenheimer
    - Walworth
    - Centerline
    - Keystone
    - Metraflex
    - Techno Corporation
    - Nibco
    - Val-Matic
    - Milwaukee
    - Stockham
    - Golden Anderson
  - Non-Slam Check Valves - 2 Inch and smaller
    - Bronze body

        - 200 psi @ 250 degrees F
        - Threaded ends
        - Resilient seats
        - Center guided spring loaded disk
    - Non-Slam Check Valves – 2 1/2 Inch and larger
        - Class 125/ 250 cast iron or stainless steel body
        - Replaceable lapped bronze seat and balanced twin bronze flappers or bronze center guided disc and stainless steel trim
        - Designed to open and close at approximately one foot differential pressure
        - Twin flappers or center guided disc shall be loaded with a stainless steel spring to assure even non-slam checking action
        - EPDM seals
- Lift Check Valves
    - Approved Manufacturers
        - Crane
        - Jenkins
        - Luckenheimer
        - Walworth
        - Conbraco
        - Metraflex
        - Milwaukee
        - Nibco
        - Stockham
    - Lift Check Valves 2 Inch and Smaller
        - Class 125 (or as required), cast bronze body and cap conforming to ASTM B 62
        - Horizontal or angle pattern, lift type valve, with stainless steel spring, bronze disc holder with renewable "Teflon" disc and threaded ends
        - Capable of being refitted and ground while the valve remains in the line
- Solenoid Valves
    - Approved Manufacturers
        - Asco
        - General Controls
        - Skinner

- Magnatrol Valve Corp.

- Consist of a solenoid (electro-magnet) with its core and a valve body containing one or more orifices
  - Solenoid mounted directly on the valve body
- Response time from fully open or closed to fully closed or open shall be slow acting
- 2 / 3 / 4 way type valves as required
- Normally open or normally closed operation as required for proper operation of the system for protection against freeze, fire and safety.
- Enclosures shall meet the ICS-6 ANSI/NEMA standard and UL standard 429, 508 and/or 1002 as follows:
  - Type 1: General Purpose
  - Type 2: Drip proof
  - Type 3 and 3S: Raintight, Dust tight and sleet (ice) resistant
  - Type 3R: Rainproof, sleet (ice) resistan
  - Type 4: Watertight and dust tight
  - Type 4X: Watertight, Dust tight and Corrosion resistant.
  - Type 6: Submersible
  - Type 6P: Submersible, prolonged submersion at a limited depth
  - Type 7: Explosion proof, Class I, Division 1, Group A (acetylene); B (hydrogen); C (ethyl- ether vapors, ethylene or cyclopropane); D (gasoline, hexane, naphtha, benzene, butane, propane, alcohol, acetone, benzol, lacquer, solvent vapors or natural gas)
  - Type 9: Dust-ignition proof, Class II, Group E (metal dust); F (carbon black coal or coke dust); G (flour starch or grain dust)
  - Operating temperatures shall range from 185 degrees F to 842 degrees F for T1 through T6 code numbers
- Minimum ambient temperature limitation
  - 32 degrees F (0 degrees C) for any valve which contains water or water vapor
  - 0 degrees F (-18 degrees C) where freezing water is not a factor
    - Special construction for ambient temperature down to -40 degrees F (-40 degrees C)
- Maximum ambient temperature limitation of 180 degrees F (82 degrees C).
- Parts in contact with fluid shall be brass, bronze, or stainless steel; core tube, 305 stainless steel; core and plug nut, 430 F stainless steel; Seal-BUNA "N"; shading coil-copper; disc-BUNA "N" and Nylon; Spring, 302 stainless steel (General Service)

- Manual reset safety shut-off valve shall open manually and close upon interruption of current
- Electric current shall be AC of voltage shown on Division 26 drawings

- Drain Valves
  - For HVAC and Plumbing Hydronic Systems
  - Ball Valve with Threaded Hose End and Cap with Chain
- General Execution
  - Isolation valves for HVAC equipment shall be accessible and mounted within equipment cabinet or housing as afforded by fabrication or, if not possible, immediately adjacent to the equipment
  - Select valves with the following ends or types of pipe/tube connections
    - Copper Tube Size 2 Inch and Smaller: Solder ends, except in heating hot water which shall have threaded ends
    - Steel Pipe Sizes 2 Inch and Smaller: Threaded or grooved-end
    - Steel Pipe Sizes 2-1/2 Inch and Larger: Flanged or grooved end
    - At all piping hot taps provide a gate valve with the hot tap and a butterfly valve for shut-off service
      - Hot taps shall be provided only where approved by the engineer

CONTINUED ON NEXT PAGE

## Valve Application Table

(Where sizes overlap, choice of either type)

| SERVICE | VALVE TYPE |
|---|---|
| Plumbing Water Services; 3" or smaller | Ball Valve |
| Plumbing Water Services; 2-1/2" and larger | Butterfly Valves |
| Plumbing Pressure Reducing Bypass; all sizes | Globe Valve |
| Plumbing Balancing Service; 2" and smaller | Calibrated Balancing Valve See Section 15135 |
| Plumbing Balancing Service; 2-1/2" and larger | |
| HVAC Hydronic Piping; 3" and smaller | Ball Valve |
| HVAC Hydronic Piping; 2-1/2" and larger | Butterfly Valve |
| HVAC Hydronic Pressure Reducing Valve Bypass; all sizes | Globe Valve |
| HVAC Hydronic Balancing valve; 2" and smaller | Calibrated Balancing Valve |
| HVAC Hydronic Balancing Valve; 2-1/2" and larger | |
| HVAC & Plumbing Check Valves; 2" and smaller | Swing Check |
| HVAC & Plumbing Pump Discharge Check Valve; | Non-Slam Spring Loaded |
| Sewage Ejector and/or Sump Pump | Swing Check, (Provide outside weighted lever or spring for 2-1/2" and larger) |

- Locate valves for easy access and provide separate support where necessary
- Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down
  - Unions are not required on flanged devices
- Install 3-valve bypass around each pressure reducing valve using throttling type valves
- Gate and globe valves shall be installed with the stem in the upright position
- In overhead horizontal piping, ball valves shall be installed with the handle in the side or bottom of the piping
- Butterfly valves shall be installed with the stem within 45 degrees of the horizontal position
- The handle of quarter turn valves shall open in the direction of flow
  - Quarter turn valves with hand wheels or chain wheels located so that the position indicator is visible from the floor without the use of a ladder or climbing on equipment or piping

- Installation of Check Valves installed for proper direction of flow
  - Swing Check Valves: Install in horizontal position with hinge pin level
  - Wafer Check Valves: Install between 2 flanges in horizontal or vertical upward flow position
  - Lift Check Valve: Install in piping line with stem upright and plumb

- Butterfly Valve Motorized Actuators
  - Coordinate with the control system installer to set up all end switches, pilot valves and control panels
  - Provide electric valve actuator power in accordance with Division 26
  - Provide min 80 psig main air piping to pneumatic actuators (existing or individually replaced pneumatic actuators, only)
  - Set travel stops as recommended by the valve manufacturer or as required
    - Stop just short of seating to allow a minimal amount of bleed
    - Set to shut off but not fully seat.
  - Locate pilot positioners and valve position indicators so that they will be visible from the floor or roof surface, without the need of a ladder or climbing over equipment and piping.

## 23 05 29 Hangers and Supports for HVAC Piping and Equipment

- In the absence of any other information, work shall be provided in accordance with
  - Applicable plumbing codes pertaining to product materials and installation of supports and anchors.
  - Hangers and supports shall comply with NFPA
  - NFPA standard No. 13 when used as a component of a fire protection system
  - NFPA Standard No. 14 when used as a component of a standpipe system
  - NFPA 99 medical gas systems
  - Hangers, supports, and components shall be listed and labeled by either
    - UL and FM where used for fire protection piping systems.
    - Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL)
      - Hangers, supports, and components shall be listed and labeled by a NRTL where used for fire protection piping systems
      - The term "NRTL" shall be as defined in OSHA Regulation 1910.7
  - SMACNA Duct Manuals
    - MSS Standard Compliance for pipe hangers and supports
- Submittals
  - Product Data
    - Installation instructions for each type of support and anchor
    - Pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support
  - Shop Drawings
    - Manufacturer's assembly-type shop drawings for each type of support and anchor
    - Dimensions, weights, required clearances
    - Methods of assembly of components.
  - Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements
  - Maintenance Data
    - Maintenance data and parts list for each type of support and anchor
  - Closeout
    - Submittals listed above updated to record status

- Pipe Hangers and Supports
  - Approved Manufacturers
    - B-Line Systems Inc.
    - ANVIL International
    - PHD Manufacturing, Inc.
    - Unistrut Metal Framing Systems
    - Hubbard Enterprises (Supports for domestic water piping)
    - Specialty Products Co. (Supports for domestic water piping).
  - Factory fabricated of materials, design, and manufacturer complying with MSS SP-69
    - Galvanized coating where piping and equipment that will not have field-applied finish
    - Nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing
  - Adjustable Clevis Hanger: MSS Type
    - Steel Pipe, size 3/8" thru 30", Type 1
    - Non-insulated Copper Pipe, size 1/2" thru 4", Type . (PVC Coated)
    - Cast Iron Pipe, size 4" thru 24", Type 1
  - Adjustable Swivel Ring for Non-insulated Pipe: MSS Type
    - Steel Pipe, size 1/2" thru 8", Type 7
    - Copper Pipe, size 1/2" thru 4", Type 7 (PVC Coated)
  - Pipe Clamps: MSS Type
    - Steel Pipe, size 3/4" thru 24", Type 8
    - Copper Pipe, size 1/2" thru 4", Type 8 (PVC Coated)
  - U Bolts: MSS Type
    - Steel Pipe, size 1/2" thru 30" Type 24
    - Copper Pipe, size 1/2" thru 8", Type 24 (PVC Coated)
  - Straps: MSS Type 26
  - Pipe Stanchion Saddle: MSS Type 37
  - Yoke & Roller Hanger: MSS Type 43
  - Hanger Rods: Continuous threaded steel, sizes as required
  - Hangers
    - Hot Pipes
      - 1/2" through 1-1/2": Adjustable wrought steel ring
      - 2" through 5": Adjustable wrought steel clevis

- 6" and Over: Adjustable steel yoke and cast iron roll

- Cold Pipes
  - 1/2" through 1-1/2": Adjustable wrought steel ring
  - 2" and Over: Adjustable wrought steel clevis
- Multiple or Trapeze
  - Structural steel channel (with web vertical and engineered for the specific applications), with welded spacers and hanger rods
  - Provide cast iron roll and base plate for hot pipe sizes six inches and over
  - Provide hanger rods one size larger than for largest pipe in trapeze
  - If the deflection at center of trapeze exceeds 1/360 of the distance between end hangers, install additional hanger at mid-span or use larger channel

o Wall Supports for Horizontal Steel Pipe

- ½ inch through 4inches: Offset or straight j-hook
- 4 inches and Over: Welded steel bracket Type 31, 32 or 33 and wrought steel clamp
- Provide adjustable steel yoke and cast iron roll Type 44 for hot pipe 200° F and over and for sizes six inches and over

o Supports for Vertical Pipe

- Steel riser clamp, Type 8

o Upper Attachments

- For attaching hanger rods to structural steel I-beams
  - Provide adjustable beam clamp, MSS-Type 21
  - Attach to bottom flange of beam
- For attaching hanger rods to bar joists
  - When bottom chord is constructed of structural steel angles, provide square washer
  - Place hanger rod between backs of the two angles and support with the washer and dual locking nuts on top of the angles
  - Spot weld washer to angles
  - When bottom chord is constructed of round bars, provide Elcen No. 137 bar joint washer or equal

- Saddles, Shield and Thermal Shield Inserts

o Approved Manufacturers

- ANVIL International

        - Pipe Shields, Inc.
        - B-Line
        - Insulated Saddle Shield Insert Product Inc.
    - Protection Saddles
        - MSS Type 39
        - Fill interior voids with segments of insulation matching adjoining insulation
    - Protection Shields
        - MSS Type 40
        - 180 degrees arc
        - Galvanized steel
        - Minimum 12 inches long, to prevent crushing of insulation
    - Thermal Shield Inserts
        - Provide 100-psi minimum compressive strength, waterproof, asbestos-free calcium silicate, encased with a sheet metal enclosure
        - Insert and shield shall cover the entire circumference or the bottom half circumference of the pipe
        - Length recommended by the manufacturer for pipe size and thickness of insulation
        - For cold piping, calcium silicate shall extend beyond the sheet metal shield to allow overlap of the vapor barrier
        - Where piping 4 inches and larger is supported on trapeze or pipe rollers, provide double thickness shields
        - For piping 12 inches and over, provide 600 psi calcium silicate structural insert
- Roof Equipment Supports
    - Approved Manufacturers
        - Custom Curb, Inc.
        - Pate Co.
        - Thycurb Div.; Thybar Corp.
        - Vent Products, Inc.
    - Provide details on drawings
- Roof Conduit and Piping Supports
    - Approved Manufacturers per
        - 22 05 29 Hangers and Supports for Plumbing Piping and Equipment
        - 26 05 29 Hangers and Supports for Electrical Systems

- Concrete Inserts and Anchors
  - Approved Manufacturers
    - Unistrut Metal Framing Systems
    - Hilti
    - ITW Ramset/Red Head
    - Power-Strut
    - B-Line
  - Inserts
    - Galvanized carbon steel case with square threaded concrete insert nut for hanger rod connection; top lugs for reinforcing rods, nail holes for attaching to forms
    - Required all areas having poured in place concrete construction
  - Size inserts to suit threaded hanger rods
  - Fasteners attached to concrete ceilings to be vibration and shock resistant
    - Concrete insert per MSS SP 69, Type 18
    - Powder driven fasteners
      - Require approval of architect and structural engineer
      - Fastener shall be capable of holding a test load of 1000 pounds where the actual load does not exceed 50 pounds
    - Self-drilling expansion shields
      - Load applied not to exceed one-fourth the proof test load required
      - Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.
  - Anchors
    - Carbon steel, zinc plated and coated with a clear chromate finish
    - Drilled holes or self-drilling anchors
- Installation
  - Hangers and Supports
    - Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible
    - Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size, or install intermediate supports for smaller diameter pipe
    - PROHIBITED
      - Use of wire or perforated metal to support piping

- Support piping from other piping

- Support fire-water piping independently from other piping systems
- Prevent electrolysis and abrasion in support of copper tubing by use of hangers and supports which are either
  - Plastic coated
  - EPDM isolation strips
  - Duct tape or copper coated hangers are PROHIBITED
- Place a hanger within one foot of each horizontal elbow.
- Use hangers which are vertically adjustable 1 1/2 inch minimum after piping is erected.
- Support vertical steel and copper piping at every story height but at not more than 15 foot intervals for steel and 10 feet for copper
- Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers
- Where practical, support riser piping independently of connected horizontal piping
- Securely anchor and support plumbing domestic water piping in chases or walls
  - Use factory manufactured clamps and brackets connected to fixtures, waste/vent piping or brackets connected to studs
    - Wires or straps are PROHIBITED
  - Where copper supplies are connected to flush valves, support the tubing by the studs or by a fixture, not by clamping to waste/vent piping
  - Prevent copper tubes from making contact with steel brackets using fire retardant polyethylene inserts or other dielectric insulating material
    - Duct tape is PROHIBITED

o Anchors

- Install anchors at proper locations to prevent stresses exceeding ANSI requirements, and to prevent transfer of loading and stresses to connected equipment
- Install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends
- Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping. Provide shop drawing for review by Engineer.

o Sheet Metal Duct Hangers and Supports

- Provide in accordance with SMACNA HVAC duct construction standards.

- Equipment Supports
  - Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor
  - Place grout under supports for piping and equipment
  - Housekeeping bases
    - Minimum 4 inches thick minimum
    - Extended 4inches beyond machinery bedplates
  - All machinery shall be grouted under the entire bearing surface
- Prefabricated Rooftop Equipment Supports
  - Equipment Bases
    - Solid top combination equipment base with integral duct curb and stepped cant to match roof insulation
    - Base shall pitch to match roof pitch and provide level unit installation
    - Base shall be constructed of reinforced 18 gauge galvanized steel with all welded components, full mitered corners, factory installed 1-1/2 inches thick rigid fiberglass insulation, wood nailer, and galvanized steel counter- flashing
    - Base shipped as one piece
  - Equipment Rails:
    - 18 gauge galvanized steel shell, base plate, and counterflashing with factory installed wood nailer, fully mitered end sections, stepped cant to match roof insulation
    - Rails shall pitch to match roof pitch and provide level installation

## 23 05 48 Vibration and Seismic Controls for HVAC

- In the absence of any other information, work shall be provided in accordance with
  - ASHRAE "Sound and Vibration Control"
    - Minimum static deflections recommended by ASHRAE, for selection and application of vibration isolation materials and units as indicated
- Obtain vibration control products from single manufacturer whenever possible
- Engage manufacturer to provide technical supervision of installation of support isolation units produced, and of associated inertia bases (if any)
- Submittals
  - Product Data
    - Manufacturer's technical product data and installation instructions for each type of vibration control product
    - Schedule showing size, type, deflection, and location for each product furnished
    - Include data for each type and size of unit, showing isolation efficiency, stiffness, natural frequency and transmissibility at lowest operating speed of equipment
    - For spring units, show wire size, spring diameter, free height, solid-compression height, operating height, fatigue characteristics, ratio of horizontal to vertical stiffness and bases of spring-rated selection for range of loading weights
    - Include performance certifications from manufacturers
  - Shop Drawings
    - Manufacturer's assembly-type shop drawings indicating dimensions, weights, required clearances, and method of assembly of components
    - Detail bases, and show location of equipment anchoring points, coordinated with equipment manufacturer's shop drawings
    - Show structural design and details of inertia bases, steel beam bases and other custom-fabricated work not covered by manufacturer's submitted data
      - Furnish templates, anchor bolts and sleeve for equipment bases, foundations and other support systems for coordination of vibration isolation units with other work
    - Indicate scope of vibration isolation work and locations of units and flexible connections
      - Include support isolation points for piping and ductwork including risers, air housings and inertia bases

        - Include schedule of units, showing size or manufacturer's part number, and weight supported and resulting deflection of each unit
    - Maintenance Data
        - Maintenance data for each type of vibration control product
    - Closeout
        - Submittals listed above updated to record status
- Vibration Control Products
    - Approved Manufacturers
        - Korfund
        - Mason Industries, Inc.
        - Peabody Noise Control, Inc.
        - Vibration Eliminator Co.
        - Vibration Mountings & Controls
    - Fiberglass Pads and Shapes
        - Glass fiber of not more than 0.18 mil diameter
        - Produced by multiple-flame attenuation process
        - Molded with manufacturer's standard fillers and binders through 10 compression cycles at 3 times rated load bearing capacity, to achieve natural frequency of not more than 12 Hertz
        - In thicknesses and shapes required for use in vibration isolation units
    - Neoprene Pads
        - Oil-resistant neoprene sheets of manufacturer's standard hardness
        - Cross- ribbed or waffled pattern
    - Vibration Isolation Springs
        - Wound-steel compression springs, of high-strength, heat-treated, spring alloy steel with outside diameter not less than 0.8 times operating height
        - Lateral stiffness not less than vertical stiffness
        - Designed to reach solid height before exceeding rated fatigue point of steel
        - Color coated springs for ease of identification.
        - Spring shall have a minimum of 50 percent additional travel to solid
    - All-Directional Anchors
        - Acoustical pipe anchor consisting of telescopic arrangement of sizes of steel tubing separated by minimum ½ inch thickness of heavy-duty neoprene and duck, or neoprene isolation material

- Provide vertical restraints by similar material arranged to prevent vertical travel in either direction
- Design for maximum 500 psi load on isolation materials, and provide for equal resistance in any direction
- Equip anchor with threaded hole on top and 2 holes in base plate for bolting down or provide welding provisions top and bottom, where required

o Neoprene Mountings

- Consisting of neoprene element bonded between 2 steel plates that are neoprene-covered to prevent corrosion
- Minimum rated deflection of 0.35 inches
- Provide threaded hole in upper plate and 2 holes in base plate for securing to equipment and to substrate

o Spring Isolators, Free-Standing

- Vibration isolation spring Type C between top and bottom loading plates, and with pad-type Type B isolator bonded to bottom of bottom loading plate
- Include studs or cups to ensure centering of spring on plates
- Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment
  - Include holes in bottom plate for bolting unit to substrate

o Spring Isolators, Vertically-Restrained

- Type C in housing that includes vertical limit stops
- Design housing to act as blocking during erection, and with installed height and operating height being equal
- Maintain ½ inch minimum clearance around restraining bolts, and between housing and springs
- Design so limit stops are out of contact during normal operation.
- Mounting used out of doors
  - Hot dipped galvanized with cadmium plated spring
  - Certified calculation by a registered professional engineer showing ability to withstand 109 MPH wind load in 3 principal axes

o Seismic Snubbers

- Type H seismic snubber where Earthquake Restraint is indicated

o Thrust Restraints

- Consisting of spring elements in series with neoprene pad
- Spring deflection same as for equipment loading

- Design so thrust restraints can be pre-set and adjusted in field
- Attach horizontal restraints at centerline of thrust and symmetrically on either side of unit
- Provide same deflection as isolated equipment
- Select load to provide ¼ inch maximum displacement under full system operating pressure

o Equipment Rails

- Where rails or beams are required for use with isolator units to support equipment, provide steel beams complying with ASTM A36, with minimum depth of 6 inches or 0.10 x span of beam between isolators (whichever is greater)
- Welded bracket at each end of beams, and anchor each end to spring isolator unit
- Bolt holes in beams matching anchor bolt holes in equipment
- Provide beams of section modules indicated or, if not indicated, selected for normal-weight equipment loading to limit static load stress to 16,000 psi
- Beam depth need not exceed 14 inches provided that deflection and misalignment is kept within manufacturer's acceptable limits.

o Fabricated Equipment Bases

- Where supplementary bases are required for use with isolator units to support equipment (base not integral with equipment), provide welded rectangular unit, fabricated of structural steel shapes, plates and bars complying with ASTM A36
- Welded support brackets and anchor base to spring isolator units
- Arrange brackets to result in lowest possible mounting height for equipment, but provide minimum of 1 inch where ever possible
- Bolt holes in base matching anchor bolt holes in equipment
- Auxiliary motor slide base under motor or motor slide rails for adjusting belt tension
    - Design primary base for bolting of rails or slide base in position
- Where sizes of base framing members are not indicated, fabricate base with depth of structure not less than 0.10 x longest span of base, rigidly braced to support equipment without deflections or distortions which would be detrimental to equipment or equipment performance
- Beam depth need not exceed 14 inches provided that deflection and misalignment is kept within manufacturer's limits

o Inertia Base Frames

- Where inertia bases are required for use with isolation units to support equipment, provide rectangular structural beam channel, or complete sheet metal box concrete forms for floating foundations, with materials complying with ASTM A36
- Frame unit as shown or, if not shown, with minimum depth of 0.08 x longest dimension of base, but not less than 6 inches deep
- Size frame as shown or, if not shown, so that weight of frame plus concrete fill will be greater than operating weight of equipment supported
- Steel reinforcing both ways with both ends of reinforcing butt-welded to base framing.
- Welded support brackets and anchor base frame to spring isolator units
- Anchor bolts, located as required for equipment anchorage and supported for casting of concrete
    - Locate bolts as indicated or, if not indicated, locate bolts so that operating weight of equipment will be centered both ways on inertia base
- Adjustable bolts in pipe sleeves
- Mounting bracket to provide 1 inch floor clearance.
- Sufficient mass to allow ¼ inch maximum displacement under starting and normal conditions

o Roof-Curb Isolators

- Fabricated frame units sized to match roof curbs, formed with isolation springs Type C between extruded aluminum upper and lower sections, which are shaped and positioned to prevent metal-to-metal contact
- Continuous airtight and waterproof seal between upper and lower extrusions
- Include provisions for anchorage of frame unit to roof curb, and for anchorage of equipment to unit

o Isolation Hangers

- Units formed with brackets and including manufacturer's standard compression isolators of type indicated
- Design brackets for 5 times rated loading of units
- Fabricate units to accept misalignment of 15 degrees off center in any direction before contacting hanger box, and for use with either rod or strap type members and including acoustical washers to prevent metal-to-metal contacts
- Vibration isolation spring Type C with cap in lower pad-type isolator rubber hanger element in bottom, securely retained in unit

        - Neoprene element, with minimum deflection of 0.35inch, securely retained in hanger box
    - Riser Isolators
        - Suspend risers from, or support risers by, spring hangers Type ND or spring isolators Type F
        - Wherever possible, anchor risers at central point with resilient anchors Type D
        - Provide hanger or mounting deflection of 0.75 inches except in those expansion locations where additional deflection is required to limit deflection or load changes to +25 percent of initial deflection
        - Sliding guides held in position by resilient anchors, located between anchor points and end of piping, spaced as indicated
    - Flexible Pipe Connectors
        - Non-ferrous piping
            - Bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose
        - Ferrous piping provide
            - Stainless steel hose covered with stainless steel wire braid with NPT steel nipples or 150 psi ANSI flanges, welded to hose.
            - Neoprene or EDPM is PROHIBITED.
- General Installation
    - Ensure units do not exceed rated operating deflections or bottom out under loading, and are not short- circuited by other contacts or bearing points
    - Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation
    - Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces
    - Adjust leveling devices as required to distribute loading uniformly onto isolators
        - Shim units as required where substrate is not level
    - Install inertia base frames on isolator units so that minimum of 1 inch clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation
    - For air handling equipment, install thrust restraints as indicated, and also wherever thrust exceeds 10 percent of equipment weight
    - Locate isolation hangers as near overhead support structure as possible
    - Weld riser isolator units in place as required to prevent displacement from loading and operations

- Flexible Pipe Connectors
  - Install on equipment side of shutoff valves
  - Horizontally and parallel to equipment shafts wherever possible

- Examination of Related Work
  - Installer of vibration isolation work shall observe installation of other work related to vibration isolation work, including work connected to vibration isolation work; and, after completion of other related work (but before equipment startup), shall furnish written report to engineer listing observed inadequacies for proper operation and performance of vibration isolation work
  - Report shall cover, but not necessarily be limited to
    - Equipment installations (performed as work of other sections) on vibration isolators
    - Piping connections including flexible connections
    - Ductwork connections including provisions for flexible connections
    - Passage of piping and ductwork which is to be isolated through walls and floors
  - Do not start-up equipment until inadequacies have been corrected in manner acceptable to vibration isolation installer
- Upon completion of vibration isolation work, prepare report showing measured equipment deflections theoretical floor deflection and isolation efficiency for each major item of equipment

## 23 05 53 Identification for HVAC Piping and Equipment

- In the absence of any other information, work shall be provided in accordance with ANSI A13.1 Identification of Piping Systems
- Submittals
  - Product Data
    - Manufacturer's technical product data and installation instructions for each identification material and device required
  - Schedules
    - Submit valve schedule for each piping system, typewritten and reproduced on 8-1/2" x 11" bond paper
    - Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), size of valve, and variations for identification (if any)
    - Only tag valves which are intended for emergency shut-off and similar special uses, such as valve to isolate individual system risers, individual floor branches or building system shut off valves
  - Closeout
    - Submittals listed above updated to record status
    - In addition to mounted copies, furnish extra copies for Maintenance Manuals
- Approved Manufacturers
  - Life Guard
  - T & B Westline
  - W. H. Brady Co., Signmark Div.
  - Allen Systems, Inc.
  - Brimar Industries, Inc.
  - Industrial Safety Supply Co., Inc.
  - Seton Name Plate Corp.
  - PVC Specialties
- Coordinate project requirements or special items and methods with LPS OMC and LPS PM
  - LPS OMC and LPS PM review and approval of all naming conventions is REQUIRED prior to procurement
- Mechanical Identification Materials
  - Manufacturer's standard products of categories and types required for each application as referenced in other Division 23 sections

- Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category

- Painted Identification Materials
  - Stencils
    - Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with ANSI recommendations for piping or to match existing size in existing building but
      - Not less than 1-1/4" high letters for ductwork
      - Not less than 3/4" high letters for access door signs and similar operational instructions
  - Stencil Paint
    - Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade
  - Identification Paint
    - Standard identification enamel of colors indicated or, if not otherwise indicated comply with ANSI for colors or to match existing building standard identification

- Plastic Pipe Markers
  - Snap-On Type
    - Manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers
  - Insulation
    - 1 inch thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F. (52 degrees C.) or greater
      - Cut length to extend 2inches beyond each end of plastic pipe marker
  - Small Pipes
    - External diameters less than 6 inches (including insulation if any)
      - Full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods
        - Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
        - Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2inch
  - Large Pipes

        - External diameters of 6inches and larger (including insulation if any)
            - Full-band or strip-type pipe markers, but not narrower than 3 times letter height (and of required length), fastened by one of the following methods
                - Steel spring or non-metallic fasteners
                - Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2inches wide; full circle at both ends of pipe marker, tape lapped 3inches
                - Strapped-to-pipe (or insulation) application of semi- rigid type, with manufacturer's standard stainless steel bands
    - Lettering
        - Comply with piping system nomenclature as specified, scheduled, shown, or to match existing building lettering nomenclature system and abbreviate only as necessary for each application length
    - Arrows
        - Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic
- Plastic Duct Markers
    - Manufacturer's standard laminated plastic, duct markers
    - For hazardous exhausts, use colors and designs recommended by ANSI A13.1.
    - Include the following:
        - Direction of air flow
        - Duct service (supply, return, exhaust, etc.)
- Plastic Tape
    - Manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick
    - 1 ½ inches wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6 inches
    - 2 ½ inches wide tape for larger pipes
    - Color: Comply with ANSI A13.1, except where another color selection is indicated
- Underground-Type Plastic Line Markers
    - Manufacturer's standard permanent, bright- colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6inches wide x 4 mils thick
    - Tape with printing which most accurately indicates type of service of buried pipe.

- Multi-ply tape consisting of solid aluminum foil core between 2-layers of plastic tape

- Valve Tags
  - Brass Valve Tags
    - 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4inch high letters and sequenced valve numbers 1/2inch high, and with 5/32inch hole for fastener
    - 1 1/2inch diameter tags, except as otherwise indicated.
    - Fill tag engraving with black enamel
  - Plastic Laminate Valve Tags
    - Manufacturer's standard 3/32 inch thick engraved plastic laminate valve tags, with piping system abbreviation in ¼ inch high letters and sequenced valve numbers ½ inch high, and with 5/32inch hole for fastener
    - 1 1/2 inches sq. black tags with white lettering, except as otherwise indicated
    - Size, shape and color combination as specified or scheduled for each piping system
  - Plastic Valve Tags
    - Manufacturer's standard solid plastic valve tags with printed enamel lettering, with piping system abbreviation in approximately 3/16inch high letters and sequenced valve numbers approximately 3/8inch high, and with 5/32 inch hole for fastener
    - 1 1/8 inches sq. white tags with black lettering
    - Size, shape and color combination as specified or scheduled for each piping system.
  - Valve Tag Fasteners
    - Manufacturer's standard solid brass chain (wire link or beaded type), and solid brass S- hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose
  - Access Panel Markers
    - Manufacturer's standard 1/16 inch thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve
    - 1/8 inch center hole to allow attachment
- Valve Schedule Frames
  - For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls
  - Frames of finished hardwood or extruded aluminum

  - Non-glare type sheet glass
- Engraved Plastic-Laminate Signs
  - Engraving stock melamine plastic laminate, complying with FS L-P-387, in the sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black with white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate
  - 1/8 inch thick, except as otherwise indicated
  - Self-tapping stainless steel screw fasteners, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate
- Plasticized Tags
  - Manufacturer's standard pre-printed or partially pre-printed accident-prevention tags, of plasticized card stock with matt finish suitable for writing, approximately 3-1/4inch x 5-5/8 inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary wording (as examples; DANGER, CAUTION, DO NOT OPERATE).
- Lettering and Graphics
  - Coordinate names, abbreviations and other designations used in mechanical identification work with LPS OMC and LPS PM
    - Numbers, lettering, and wording as coordinated with and approved by LPS OMC and LPS PM for proper identification and operation/ maintenance of mechanical systems and equipment
    - Where multiple systems of same generic name are shown and specified, provide identification which indicates individual system number as designated on the drawings or schedule as well as service
- Ductwork Identification
  - Identify air supply, return, exhaust, intake and relief ductwork and duct access doors with duct markers; or provide stenciled signs and arrows, showing ductwork service and direction of flow, in black or white (whichever provides most contrast with ductwork color)
  - Existing buildings
    - Match the method in the building
  - Spaces where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar), and at 50 foot spacing along exposed runs
  - Duct markers or stenciled signs on each access door in ductwork and housings, indicating
    - Purpose of access (to what equipment)

        - Maintenance and operating instructions
        - Appropriate safety and procedural information
    - Access doors are concealed above acoustical ceilings or similar concealment, plasticized tags may be installed for identification in lieu of specified signs is acceptable
- Piping System Identification
    - Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow
    - Existing buildings
        - Match the method in the building
    - Plastic pipe markers
        - Install on pipe insulation segment where required for hot non-insulated pipes.
    - Stenciled markers
        - Including color-coded background band or rectangle, and contrasting lettering of black or white
        - Extend color band or rectangle 2 inches beyond ends of lettering
        - Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided
    - Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations
        - Near each valve and control device
        - Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern
        - Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures
        - At access doors, manholes and similar access points which permit view of concealed piping
        - Near major equipment items and other points of origination and termination
        - Spaced intermediately at maximum spacing of 25 feet along each piping run, except reduce spacing to 15' in congested areas of piping and equipment
        - On piping above removable acoustical ceilings
- Underground Piping Identification

- During back-filling/top-soiling of each exterior underground piping systems, install continuous underground- type plastic line marker, located directly over buried line at 6 inches to 8 inches below finished grade
- Where multiple small lines are buried in common trench and do not exceed overall width of 16 inches, install single line marker
- For tile fields and similar installations, mark only edge pipe lines of field

- Valve Identification
  - List each tagged valve in valve schedule for each piping system
    - Building services main shut-off valves
    - Each individual system main shut-off valves
    - Each individual system riser shut-off valves
    - Each individual system floor shut-off valves
    - Each individual system major branch shut-off valves
  - Mount valve schedule frames and schedules in mechanical equipment rooms
    - Where more than one major mechanical equipment room is shown for project, install mounted valve schedule in each major mechanical equipment room, and repeat only main valves which are to be operated in conjunction with operations of more than single mechanical equipment room
- Mechanical Equipment Identification
  - Minimum 2 inch x 4 inch engraved plastic laminate equipment marker on each individual item of mechanical equipment
  - Provide marker for the following general categories of equipment
    - Main building systems control and operating valves, including safety devices and hazardous units such as gas outlets
    - Room thermostats, except gun tag labels are acceptable for room thermostats
    - Fuel-burning units including boilers, furnaces, heaters, stills and absorption chillers
    - Pumps, compressors, chillers, condensers, and similar motor-driven units
    - Heat exchangers, cooling towers, heat recovery units and similar equipment
    - Fans and blowers
    - Air terminal units
    - Tanks and pressure vessels
    - Water treatment systems and similar equipment

- Minimum 1/4 inch high lettering for name of unit
- In addition to the identified unit, inform operator of
  - Operational requirements
  - Safety and emergency precautions
  - Warn of hazards and improper operations

## 23 05 93 Testing, Adjusting, and Balancing for HVAC

- In the absence of any other information, work shall be provided in accordance with
  - ASHRAE: ASHRAE Handbook, Systems Volume, Testing, Adjusting, and Balancing
  - NEBB: “Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems”
  - SMACNA: “HVAC Systems-Testing, Adjusting & Balancing”
- Testing and balancing of all systems by one Testing, Balancing and Adjusting firm
  - Mechanical contractor to provide services of an independent testing and balancing agency specializing in the testing, adjusting and balancing of environmental system.
  - Fieldwork performed by qualified technicians certified by either
    - Testing, Adjusting and Balancing Bureau (TABB)
    - National Environmental Balancing Bureau (NEBB)
    - Associated Air Balance Council (AABC)
  - The Testing & Balancing Contractor shall have a minimum of three years’ experience in testing and balancing mechanical systems
    - Where required, previous experience in testing and balancing variable air volume laboratory fume hood systems in the last two years
      - Qualification submission must include a detailed resume describing past project experience in laboratory variable air volume systems, a list of projects, including peoples’ names, phone numbers and addresses of references
- Test, adjust and balance the following mechanical systems and the mechanical equipment associated with these systems:
- Approved Contractors
  - JEDI Balancing
  - Air Right Inc.
  - Lawrence H. Finn & Assoc.
  - Griffith Engineering Service
  - JPG Engineering
  - Rocky Mountain Balancing Co.
  - TAB Services, Inc.
  - Complete Mechanical Balancing
  - Double T Balancing Company

- Controlled Air, Inc.
- Midwest Engineering
- Checkpoint Balance
- Approval of others
  - Any Testing and Balancing firm desiring to offer their services for this work shall submit their qualifications to architect/engineer not less than seven (7) working days before the bid date
  - Approval or disapproval will be given on each request, and this action will be given inwriting prior to bidding the work

- Preliminary Submittals
  - Within ten (10) days of award of the contract submit the name of the Test and Balance Contractor who will be performing the work including
    - Complete list of technicians performing the field work
    - Include photocopy of current certification by either NEBB, AABC, or TABB certification agencies.
    - Only those technicians included in the submittal shall perform the work
    - Personnel or staff used to perform the work without prior approval of the engineer, who are not included in the submittal, shall be grounds for rejecting the test and balance report and the project in whole
  - Meet all requirements of Section 23 05 00 as applicable.
  - List of all instrumentation to be used on an individual project and include calibration dates
    - Submit calibration curves
    - If more than one instrument of a similar type is used, a comparison of individual readings should be made
    - The variation between instrument readings should not exceed plus or minus 5%
  - Preliminary Systematic Procedure where required on a per project basis as determined by the engineer and approved by LPS OMC and LPS PM as noted below
    - PDF and two (2) hard copies of a Preliminary Systematic Procedure per engineer's requirements

- Final Reports
  - Per LPS General Conditions of the Contract and other sections of applicable Divisions for supplemental requirements.
  - PDF and two (2) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to substantial completion
  - Meet all requirements of Section 23 05 00 as applicable.

- If more than two reports are made by the contractor, the Owner reserves the right to charge the contractor for subsequent reviews by their consultants

- Sequencing and Scheduling
  - Notify contractor, engineer, and architect in writing of conditions detrimental to the proper completion of the test and balance work
  - Prepare a project schedule
    - Indicate critical path of the balancing process and shall incorporate both requirements of other contractors necessary to meet test and balance commitments and process flow of test and balance work
    - Coordinate with general and mechanical contractors and insert critical steps into project master schedule
- Belts, Sheaves, Impellers
  - Refer to specific equipment sections and Section 23 05 00 for additional requirements.
  - The Testing & Balancing Contractor shall coordinate with the Mechanical Contractor to supply correctly sized drive belts and sheaves
    - Impellers shall be trimmed or replaced by the Mechanical Contractor and shall be correctly re-sized and coordinated by the Test and Balancing Contractor
  - Test & Balance Contractor determines the fan belt and sheave replacement necessary for final balance condition for specified air quantity when the VFD is operating in the by-pass mode for final field conditions, without placing the motor over its nameplate amp rating
- Preliminary Procedures
  - Testing and balancing shall not begin until the system has been completed and is in full working order and the following project conditions have been determined suitable for start of work
    - Preliminary Testing & Balancing Contractor requirements shall be ascertained prior to the commencement of work through a review of the project plans and specifications
      - Visual observations at the site during construction shall be made to determine the location of required balancing devices, that they are being installed properly, and in an accessible location
      - Verify systems do not exhibit excessive sound and/or vibration levels
      - Immediately report in writing any deficiencies to the contractor, engineer, and architect
  - RESTRICTED procedures requiring per project review and approval due to added cost and engineering time to a project
    - Prior to air balance work inspect, verify, correct the system for

- Duct leakage (obtain pressure test results)
- Filters are installed
- Filters are changed if they are dirty
- Correct fan rotation
- Equipment vibration
- Automatic dampers for proper operation
- All volume control dampers and outlets are wide open

▪ Prior to any hydronic, domestic water or applicable system balancing work, inspect, verify, correct the system for

- Plugged strainers
- Proper pump rotation
- Proper control valve installation and operation
- Air locks
- Proper system static pressure to assure a full system
- Proper flow meter and check valve installation
- All throttling devices and control valves are open

▪ In remodel areas

- A complete preliminary test and balance report shall be accomplished prior to any work
- Obvious deficiencies shall be identified at that time
- A complete report of all readings, recommendations, etc. shall be submitted to the engineer

General System and Equipment Procedures

o Pressure relationships indicated on drawings take priority over air quantities

o Mark equipment settings with paint, to show final settings at completion of test-adjust-balance work including

▪ Damper control positions

▪ Balancing cocks

▪ Circuit setters

▪ Valve indicators

▪ Fan speed control settings and similar controls and devices

o Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommend by the original installer

o Measure, adjust and report

- Equipment running motor amps and power factor
- KW
- Rated motor amperage
- Listed motor power factor
- Voltage
- All nameplate data
- Perform these measurements for all equipment operational modes

o Check and adjust equipment belt tensioning

o Check keyway and setscrew tightness

- Report any loose screws and notify Mechanical Contractor prior to equipment balancing

o Record and include in report all equipment nameplate data

o Verify that all equipment safety and operating controls are in place, tested, adjusted, and set prior to balancing

o Verify that manufacturer start-up has occurred per specification prior to balancing

Air Side Systems and Equipment Procedures

o Filters shall be restricted to increase pressure drop to 50% of span between initial pressure drop and final recommended pressure drop for setting final airflows for fans

- Check fan motor amps with clean filters and simulated loaded filters, and report for each piece of equipment
- Equipment shall be supplied with clean filters upon completion of balance
- Balance and report air quantities

o Supply/Return Air Systems

- Balance and report supply and return diffuser/grille quantities
- Provide full pitot traverses in duct mains downstream of supply fans, upstream of return fans, and in each zone duct downstream of a multi-zone unit
  - For VAV systems perform these at the system diversity condition (if any)
  - Balance and report air quantities
- Provide full pitot traverses at each air terminal or duct coil
  - For VAV systems, perform these at zone maximum air condition
  - Balance and report air quantities

- Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system
- Balance and report the above measurements in all system operational/modes
  - Minimum outside air and 100% outside air economizer mode
  - VAV maximum zone air condition and system diversity condition
  - Unoccupied mode
  - Two-speed fan, both speeds
  - VFD bypass mode and full system demand
  - General Exhaust/Supply Fans

o Adjust CFM to system requirements

- For belt drive include sheave and belt exchange to deliver airflow within limits of installed motor horsepower and mechanical stress limits of the fan
  - Determine the limiting fan tip speed before increasing RPM
  - Final fan speed setting shall allow for filter loading (as applicable) and shall establish proper duct pressures for operation of zone CFM regulators
- For direct drive with speed taps
  - Set fan speed on tap which most closely approaches design CFM by adjusting the speed control
  - After adjustment, check fans ability to re-start after powering down
  - Increase setting if required for proper starting
- Measure and report static pressures upstream and downstream of all fans
- Measure and report fan RPM
- Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice

o Air Handling Units

  - On outdoor units, verify that positively or negatively pressurized curbs are free of leaks. Report

- For units with integral outside air intake and relief dampers, measure, adjust, set and report outside air, return air and relief air quantities
  - Perform this as specified under supply air systems
- Balance and report supply and return fan CFM, upstream static pressure and downstream static pressure

- Measure and report static pressure upstream and downstream of all AHU components such as coils, filters (clean and simulated dirty), dampers, etc.
- After system and fan balance is complete, perform pitot traverses on all coils in 100% heating and cooling modes
- Units with economizers shall have all measurements performed and reported at minimum outside air, 100% outside air, and a 50/50% mixed air condition
- Units with operation modes for smoke evacuation and/or pressurization shall have all measurements performed and reported for all modes
- Balance variable air volume AHU fans for system design diversity
  - Supply and return fan static pressures shall be optimized for VAV system terminal device pressure requirements
  - Report fan, motor and VFD information as previously indicated
  - Verify that an overload condition does not exist when all system VAV boxes are 100% open
- Balance all air handling unit coils and report per hydronic, gas fired, or refrigeration equipment portions of this section
- Report design fan inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice.
- Balance and report all temperatures of airside and hydronics during normal operating modes.
- Measure, adjust, set, balance and report outside air, return air and exhaust/relief air quantities for all air handling systems
  - Air quantities shall be determined by pitot traverse/direct airflow measuring procedures where ever possible, where duct/inlet conditions do not allow for accurate direct measurement of outside air the following method shall be used:

    Outside Air CFM = Supply Fan Total CFM - Return Fan Total CFM
  - In addition to the direct measuring of airflow quantities, measure and record outside air, return air and mixed air temperatures, determine thermal/mass energy balance and provide calculations to verify measured airflow quantities
  - Adjusting and setting the outside air quantity as a percentage of damper position is PROHIBITED

o General Exhaust Systems

- Balance and report exhaust grille quantities
  - Report objectionable noise
- Provide full pitot traverses at each individual exhaust riser and at each exhaust fan

- Balance and report

- Report design air device inlet or outlet size, actual inlet or outlet size, design and actual velocity through the orifice, for each terminal in the system

- Cabinet/Unit Heaters
  - Balance and report entering and leaving air temperature
    - Report airflow
  - Balance all coils per hydronic, or gas fired equipment portions of this section
- Unit Ventilators/Furnaces/Packaged Air Conditioning Units:
  - Report static pressure across all unit components
  - Balance and report supply air, return air and outside air quantities
  - Report mixed air temperature and balance coils per hydronic, electric resistance, gas fired or refrigeration portions of this section
- Laboratory and Research Facility System Requirements:
  - General requirements
    - Balance all rooms to required pressure relationships as noted on the drawings
      - Document in the test and balance report that all pressure relationships have been set as specified
    - Performance testing of the Room Pressurization Control System and the fume Hood Exhaust System shall be performed after the entire mechanical system for the building is complete
      - All systems shall have been calibrated, tested and balanced before performance testing begins
    - Performance testing shall be done by the balancing contractor in the presence of the Owner, user groups, and a representative from the Department of Environmental Health and Safety
    - The performance testing must be successfully completed before LPS will accept control of the building's mechanical system
  - Fume Hood Exhaust Systems
    - Measure and set flows for all fume hoods, flammable storage cabinets, etc.
    - Perform full Pitot traverses upstream of exhaust fans and balance and report air quantities
      - Perform this in fully open and closed hood sash positions
  - Fume Hood Exhaust System Performance Evaluation

- Demonstrate the exhaust system and pressure relationships are performing properly under the conditions listed below
- Verify that the exhaust fans on the roof are operating properly
  - Discharge dampers should be performing as specified and the fans should be operating smoothly without surging or vibrating excessively
- During each step in the testing procedure, note any rooms, which exhibit excessive noise
- Testing Conditions
  - With all fume hood sashes closed, check the relative pressure relationships with smoke in several rooms on each floor
  - With all fume hood sashes open, check the face velocity of the hood closest to and farthest from each exhaust riser
    - Do this on every floor
  - Close all the fume hood sashes served by one exhaust riser and open all the ones served by the other riser
    - Check the hoods with open sashes as above
    - Repeat condition for the second riser
  - Move all the fume hood sashes to a half open position
    - Check the hoods as above
  - Final balance shall be based upon diversity provided by the engineer
    - Note diversity on balance reports
    - The hood face velocities, relative pressure relationships and stable fan operation must be recorded for all five-test conditions
    - This applies to all hoods and all rooms in the wing being tested, even if the test procedure does not specifically state that particular hood or room be tested
    - Design conditions with the appropriate diversity shall be maintained.
  - The face velocity of a hood shall be considered acceptable if it is within (+) 10 feet per minute of its designed face velocity
    - Standard procedures for testing face velocity as published by SEFA (Scientific Equipment & Furniture Association) 1-1992 Laboratory Fume Hoods Recommended Practices, shall be followed

- Room Pressurization Control System Performance Evaluation:
  - Demonstrate with smoke that the correct relative pressure relationship is being maintained in each area

- Every room for which a relative pressure value was assigned on the mechanical plans shall be tested

- The testing shall be performed in each room under the following conditions
  - Door closed
  - Door open
  - In labs with fume hoods or bio-safety cabinets
    - Hood sash complete open
    - Hood sash closed
    - Hood sash partially open
  - Thermostat set to its minimum set point
  - Thermostat set to its maximum set point
  - If the correct pressure relationships cannot be demonstrated for a particular room, the room shall be retested after the problem has been corrected

- Kitchen/Service Hood Exhaust Systems
  - General Requirements
    - Balance all rooms to required pressure relationships as noted on the drawings
      - Document in the test and balance report that all pressure relationships have been set as specified
    - Performance testing of the Room Pressurization Control System and the Hood Exhaust System shall be performed after the entire mechanical system for the building is complete
      - All systems shall have been calibrated, tested and balanced before performance testing begins
    - Set, measure and report flows for all hoods
    - Perform full pitot tube traverses upstream of exhaust fans and balance and report air quantities.
      - In welded high temperature systems provide air quantities upstream of exhaust fans by summing the flows at all hoods
    - Measure and report hood capture velocity profiles
  - Exhaust system performance evaluation
    - Verify room pressure relationships with smoke tests and report
    - Testing shall be performed in each room under the following conditions
      - Door closed

- Door open
- Thermostat set to its minimum set point
- Thermostat set to its maximum set point
- If the correct pressure relationships cannot be demonstrated, the room shall be retested after the problem has been corrected

- Verify hood capture velocities are adequate with smoke tests and report
- Verify that the exhaust fans on the roof are operating properly. The fans shall be operating smoothly without surging or vibrating excessively

Hydronic Systems and Equipment

- Heating/Chilled Water Systems
  - Hydronic Systems with Meters
    - The system shall be balanced proportionally using the flow meters
    - On completion of the balance, the following information shall be recorded in the report
      - Flow meter size and brand, required flow rate and pressure drop, valve settings on meters with a readable scale, flow rate in both full coil flow and full bypass modes
      - Verify the meters are installed per the manufacturer's recommendations
      - Notify the mechanical contractor of any deficiencies before utilizing meter
  - Hydronic Systems Without Meters (thermal or terminal rated pressure drop balance)
    - System shall be balanced proportionally to the terminal ratings
    - On completion of the balance the following information shall be recorded in the report
      - Design entering and leaving water temperature/pressure, final balanced entering and leaving water temperature/pressure drop
  - For 3-way valve terminals/heat exchangers, set bypass flow to equal coil flow
  - For primary/secondary systems, set crossover/bridle to have constant flow at all conditions
  - Sample chilled and heating water and report on freeze and burst temperatures of the glycol water solution
    - Report glycol percentage
  - Perform similar operations for Hydronic heat reclaim systems
- Condenser Water Systems and Equipment

- Measure and record system static pressure with pumps off
- Where 3-way bypass is used to control condenser water temperature set the control valve pressure valve to equal tower pressure drop in full bypass mode
- Measure, set and record system gpm at all flow measurement stations

o Hydronic Coils

- Balance, measure and report inlet and outlet air temperatures for cooling and/or heating design air quantities
- Balance, measure and report coil water flow, inlet and outlet water pressure and temperature
- Evaporative cooling coils
  - Measure and report inlet and outlet wet bulb and dry bulb temperature
  - Measure and report inlet and outlet pressure
- Calculate and report face velocities across chilled water and evaporative cooling coils

o Radiators and Convectors

- Balance, measure and report GPM, inlet temperature and outlet temperature/pressure at full heating

o Heat Exchangers

- Balance, measure and report water flow for full heating
- Report inlet and outlet water pressures and temperatures for full heating

o Hydronic Pumps

- Adjust and balance pumps to provide design system flow rate, and design flow to most remote system location
  - Trim or replace impellers as necessary to achieve this
  - Do not induce false head to achieve balance results, without the prior approval of the engineer
  - Prior to trimming of impellers, notify the architect, contractor, and engineer in writing of performance of pumps with and without false head induced
- Report impeller size, flow rate, inlet and outlet water pressure and pump shut-off head
  - Provide pump curve and operating point in final report
  - Include compensations for temperature and percentage glycol

o Heating Water Boilers

- Verify that the boiler has been properly cleaned, flushed and the burner is operating properly prior to balancing
- Check and report on proper operation of boiler feed pumps

- Confirm automatic and manual air vents are working properly
  - Vent system as necessary
- Balance, measure and report boiler water flow rate, inlet and outlet temperature and pressure
- Confirm that temperature and pressure safety relief valves are located properly and in working order
- Verify proper operation of emergency power OFF switches

Plumbing Systems and Equipment

- General
  - Check, adjust and set temperature control devices to domestic hot water temperature and as indicated on drawings
  - Adjust pressure-reducing stations, report downstream system static pressure
  - Verify proper location and operation of ASME pressure and temperature relief valves
  - Measure and report residual pressure at full flow at most remote plumbing fixture; requiring highest operating pressure (usually flush valve water closets)
  - Verify that most remote fixture has hot water available semi-instantaneously with recirculation system operating. Report.
- Sewage Ejector/Sump Pumps
  - Verify proper discharge of sewage ejector and sump pump systems
  - Verify that units are meeting system demands. Report.
- Booster Pumps
  - Measure and report inlet and outlet pressure and flow rate
  - Balance pumps per Hydronic portion of this Section
- Water Heaters
  - Measure, set and report inlet and outlet temperatures
  - Balance and report per electric or gas portions of this Section
- Pure Water Distribution Systems
  - Verify and report flow at all stations
  - Verify and report operation of irradiation devices
  - Measure and report recirculation system flow rate
  - Remove, inspect and clean all system particulate filters and strainers
- Fuel Oil Systems and Equipment
  - Remove, inspect and clean all system filters/strainers
  - Verify correct operation of fuel oil tank level gauges. Report

- Verify and report operation of all pumps, feed pumps and transfer pumping systems. Verify that they are meeting system requirements

- House Compressed Air Systems and Equipment
  - Verify and Report air pressure at all system equipment quick connects and terminations
  - Remove, inspect and clean all system filters/strainers
  - Verify system can maintain overrating pressure for 8 hours with air compressor disconnected
    - Report any noticeable losses in system pressure
  - Measure, set and report storage tank air pressure
  - Verify that pressure relief valves are in place and operating correctly

Refrigeration Systems and Equipment

- Condensing Units (Air Cooled):
  - Measure and report ambient temperature, refrigerant suction and discharge pressure, oil pressure, compressor and fan KW and compressor and fan amps
  - Condensing units integral to the air moving equipment shall be measured at minimum outside air
  - Perform all measurements at all stages of cooling
- Chillers
  - Measure, balance and report inlet and outlet chilled water temperature and pressure, ambient temperature, water flow rate, oil pressure, refrigerant suction and discharge pressure, compressor/fan KW and compressor/fan amps
  - Verify proper operation of emergency power OFF switches and refrigerant sensors
  - Perform all measurements at all stages of cooling
  - Coordinate balance process with equipment manufacturer start-up representative
- Cooling Towers
  - Measure and report tower entering and leaving air wet bulb temperature
    - Compare entering wet bulb against ambient wet bulb to verify recirculation is not taking place. Report
  - Measure and report entering and leaving water temperatures
    - Report ambient wet bulb that corresponds with these measurements
  - Measure, balance and report water flow rate
- Evaporator Coils

- Measure and report temperature upstream and downstream of evaporator coils at all stages of cooling at all design air quantities
  - Calculate and report coil face velocities

Gas Fired Systems and Equipment

- General
  - Record gas pressures downstream of each pressure-reducing valve. Verify that pressures match those on construction documents and report
  - Measure and report flue temperature at all stages of heating
  - Measure and report temperatures upstream and downstream of gas-fired coils at all stages of heating at all design air quantities
  - Observe and report operation of all radiant gas fired heaters, at all stages of heating
  - Record fan data

Electrical Components Associated with Mechanical Systems

- Electric Resistance Heating Systems and Equipment:
  - Measure full load amperage at full heating and design CFM and report
  - Electric heaters in an airstreams shall have entering and leaving air temperature measured and reported for all stages of heating
- Manual and Magnetic Starters
  - Check all new and existing thermal overloads
    - Identify improperly protected equipment in report
    - Furnish and exchange thermals as required for proper motor protection
  - Motor Control Center Magnetic Starters
    - Check for correct sizing
    - Notify Electrical Contractor of discrepancies
  - Two-speed Starters
    - In addition to the above, set time delay between changes of speeds for proper operation
    - Verify windings of motor and starter are compatible prior to starting any equipment.
- Variable frequency drives
  - Coordinate balance process with equipment manufacturer start-up representative
  - Record nameplate data
  - Record motor overload setting
  - Record full load amps

Control Systems and Equipment

- General
  - Operate all temperature control systems with the temperature control contractor's representative for proper sequence of operation
    - Be responsible for calibration of flow measurement devices used as input to the temperature control system
    - All air system flow measurement stations including VAV terminals shall be calibrated against a Pitot tube traverse or air diffuser capture hood
    - Assure accuracy of all flow measurement devices or report failure to be accurate
  - Work with the controls contractor to
    - Set minimum outside air damper positions
    - Optimize VAV duct static pressure, VFD pump hydronic system pressure differential and building pressure
- Temperature Control Compressed Air Systems and Equipment
  - Verify and report air pressure at all system equipment quick-connects and terminations
  - Remove, inspect and clean all system filters/strainers
  - Verify system can maintain overrating pressure for 8 hours with air compressor disconnected
    - Report any noticeable losses in system pressure
  - Measure, set and report storage tank air pressure
  - Verify that pressure relief valves are in place and operating correctly

Life Safety Systems and Equipment

- Smoke Pressurization/Exhaust/Evacuation Mode
  - Balance and report measurements per General System and Equipment Procedures Section in this operational mode
  - Perform smoke pressurization/evacuation tests in all zones
    - Doors shall be positioned to simulate normal conditions
  - Coordinate with the Fire Department/Authority Having Jurisdiction, LPS OMC, LPS PM, and engineer for smoke test witnessing
  - Coordinate with the Fire Department/Authority Having Jurisdiction for additional testing requirements
    - Complete and submit any documentation for Fire Department/Authority Having Jurisdiction final acceptance
- Fire/Smoke Dampers and Detection Systems

- Verify that each fire/smoke damper closes when the associated duct or space detector is tripped
  - Verify that air handlers shut down and outside air dampers close as dictated by the control sequence
- Verify that air supply units shut down when smoke is detected by the associated duct detector
  - Verify that outside air dampers and system fire/smoke dampers close as dictated by the control sequence
- Report
  - Any detectors or dampers that are malfunctioning
  - Any discrepancies from the control sequence

o Engine Generator Systems and Equipment

- For remote radiators, measure and report steady state radiator system flow rate, supply water temperature and return water temperature
- Measure and report generator room steady state temperature with generator and room ventilation system running
  - Report outside air temperature at time of test
- Record pressure relationship of generator room to adjacent spaces and outside
- Verify correct sequence of operation of all intake and discharge dampers, supply/exhaust fans, etc

Sound and Vibration

o Sound Inspection and Testing:

- Prior to sound testing, all equipment that can potentially impact sound testing shall be put into operation
  - Examples include fan coil units, humidifiers, air handling units, and equipment in adjacent mechanical spaces
  - VFD systems shall be placed at 80% of full speed
- Prior to sound testing the mechanical test and balance of all systems shall be completed
- Report audible tonal characteristics such as whine, whistle, hum or rumble
  - Also report time varying sound levels or beats induced from aerodynamic instability, perform this for all rooms
- Consult ASHRAE and Owner Standards for recommended RC level for different types of rooms
  - Identify where to perform sound testing within the project area
- OPTIONAL - RESTRICTED: Consult with LPS OMC and LPS PM regarding additional project specific requirements

- Measure cooling tower sound output (DBA)
  - Perform this at full speed for VFD units
- Measure and report room sound pressures
  - At the 16, 31.5, 63, 125, 250, 500 1000, 2000, 4000, and 8000 Hz octave bands
  - Measure and report corresponding RC level
  - Testing shall be performed after full furnishing of the space
  - Perform measurements in accordance with procedures outlined in Chapter 34 and 43, ASHRAE HVAC Applications, 1995 Edition
- Noise levels at property line
  - Consult with LPS OMC, LPS PM, and Authority Having Jurisdiction for maximum noise levels at property line
  - Verify means of measurement (DBA, NC, etc.)
  - Measure and report noise levels (DBA) at the following locations
    - At the property line closest to intake and discharge louvers
    - At the property line closest to rooftop and at grade equipment such as cooling towers and chillers
    - On roof of adjacent buildings overlooking rooftop equipment within project area

- Vibration Inspection and Testing
  - Prior to vibration testing
    - All equipment shall be put into operation
    - On variable speed equipment, testing shall occur at low, medium, and high speeds
    - Mechanical test and balance of all systems shall be completed
  - Report excessive vibrations from any equipment
    - Inspect upstream and downstream duct and piping systems and report excessive vibrations
  - OPTIONAL - RESTRICTED: Consult with LPS OMC and LPS PM regarding additional project specific requirements
    - Verify that all spring and elastomeric isolation systems are installed “free-floating” and are not short circuited to structure by obstructions
    - Perform a stethoscope check on all accessible bearings and report excessive vibration or noise
    - Spring isolator efficiencies
      - Consult ASHRAE for recommended minimum spring isolator efficiencies

- Obtain undeflected isolator spring lengths from shop drawings for each piece of equipment
- Measure and report
  - Distance of spring isolator deflection for each of equipment
  - Disturbing frequency (Hz) for each piece of equipment

- Measure and report motor running speed and driven equipment running speed for each component
  - Consult ASHRAE Applications, Chapter 43, for recommended maximum RMS velocity levels and vibration criteria
- Measure and report horizontal, vertical and axial RMS velocity (in./sec.) at equipment structure or bearings
- Measure and report horizontal, vertical and axial frequency (Hz.) at equipment structure or bearings.

- Report of Work
  - References to Preliminary Systematic Procedure requirements apply only as previously approved
  - Submit PDF and two (2) bound copies of the final testing and balancing report at least fifteen (15) calendar days prior to the mechanical contractor's request for final inspection.
  - Complete reduced set of mechanical contract drawings (showing each system) shall be included in the report with all equipment, flow measuring devices, terminals (outlets, inlets, coils, fan coil units, schedules, etc.) clearly marked and all equipment designated
  - Data shall be reported on standard NEBB forms
    - Generate custom forms that contain the information in this Section when a standard NEBB form does not exist for a piece of equipment
    - All NEBB forms shall be fully filled out for this report
    - Report forms with design columns filled out shall be used from the Preliminary Systematic Procedure report submitted previously
  - The report shall include a list of all equipment used in the testing and balancing work
    - This list shall closely resemble the list submitted with the Preliminary Systematic Procedures report with any discrepancies accounted for.
  - Report systems for excessive sound and vibration per the sound and vibration inspection and testing portions of this specification
  - Substantial completion of this project will not take place until a satisfactory report is received

- The Testing & Balancing Contractor shall respond and correct all deficiencies within seven (7) days of receiving the Engineer's written review of the balancing report
- Failure to comply will result in holding payment, per the General Conditions, until all items have been corrected to the satisfaction of the engineer
- The report shall be signed by the supervising registered professional engineer and affixed with their registration stamp, signed and dated in accordance with state law

- Guarantee of Work
  - The Testing & Balancing Contractor shall guarantee the accuracy of the tests and balance for a period of 90 days from date of final acceptance of the test and balance report
  - During this period, the Testing & Balancing Contractor shall make personnel available at no cost to correct deficiencies that may become apparent in the system balance

## 23 07 00 HVAC Insulation

- Flame/Smoke Ratings
  - Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives)
    - Tested by ASTM E 84 (NFPA 255) method
    - Flame-spread index of 25 or less
    - Smoke-developed index of 50 or less
    - When tested, shall not drip flame particles, and flame shall not be progressive
  - Provide Underwriters Laboratories Inc., label or listing, or satisfactory certified test report from an approved testing laboratory
- Submittals
  - Product Data
    - Manufacturer's technical product data and installation instructions for each type of mechanical insulation
    - Schedule showing manufacturer's product number, k-value, thickness, density, and furnished accessories for each mechanical system requiring insulation
    - Detail product information and installation information for all jacketing systems.
  - Closeout
    - Submittals listed above updated to record status

  Mechanical Insulation
  - Approved Manufacturers
    - CertainTeed
    - Owens-Corning Fiberglas Corp.
    - Johns Manville Corp.
    - Knauf Fiber Glass
    - Manson
    - Armstrong World Industries, Inc.
    - Pittsburgh Corning Corp.
    - PABCO, Inc.
    - Rubatex Corp.
    - Thermal Ceramics
    - Thermal Structures

  Jacketing & Covering Products
  - Approved Manufacturers
    - Childers

- Ceel-Co
- Zeston
- Alpha Associates, Inc.

Piping Insulation

- Coordinate extent and type of underground piping and insulation with drawings and LPS OMC and LPS PM
  - Preferred method is pre-insulated piping systems
- Materials
  - Fiberglass Piping Insulation
    - ASTM C 547, Class 1 unless otherwise indicated
    - "K" factor shall be maximum 0.24 at 75 degrees F. mean temperature
    - Jacket with tensile strength of 35 lbs/in
    - Mullen burst 70 ps
    - Beach puncture 50 oz. in/in
    - Permeability .02 perm factory applied vapor barrier jacket and adhesive self-sealing lap joint
  - Cellular Glass Piping Insulation
    - ASTM C 552, Type II, Class 2
    - "K" factor shall be maximum
    - 0.29 at 75 degrees F mean temperature
  - Calcium Silicate Piping Insulation
    - ASTM C 533, Type I
    - "K" factor shall be maximum 0.45 at 500 degrees F. mean temperature
    - Compression strength 200 psi for 5 percent compression
    - Transverse strength 200 psi for 5 percent compression
    - Flexural strength 60 psi
  - Flexible Closed Cell Piping Insulation
    - ASTM C 534, Type I
    - "K" factor shall be maximum 0.27 at 75 degrees F. mean temperature
    - Water vapor permeability of 0.10 perm inches or less
    - Pre-installed on piping, or un-slit to be slipped over piping as a single piece
  - Flexible Thermal Ceramic Insulation
    - Fiber Retractory or Ceramic Fiber

- "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature
- 2000 degrees F temperature limit
- Presized glass cloth jacketing material
  - Not less than 7.8 ounces per square yard, or metal jacket

▪ Rigid Thermal Ceramic Insulating System

- Rigid thermal insulating systems are designed to specific job applications by Thermal Structures
  - Provide desired thickness, ambient air temperature desired, cold side temperature, and hot side temperature to Thermal Structures for proper design of insulating system
- "K" factor shall be a maximum of 1.5 at 1500 degrees F mean temperature
- 2000 degrees F temperature limit.

▪ Jackets for Piping Insulation

- Coordinate exterior ductwork insulation spec with details on drawings
- ASTM C 921, Type I for piping with temperatures below ambient
- ASTM C 921, Type II for piping with temperatures above ambient
  - Type I may be used for all piping
- Fitting Covers
  - UV resistant PVC, pre-molded fitting covers
  - PVC tape for cold systems
  - Serrated tacks or PVC tape for hot systems
- Aluminum Jacketing
  - T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16" corrugations and shall have a factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing
  - 0.016" thick minimum
  - Provide matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, flange fittings, valve bodies, blind ends, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof
  - Optional jacketing color coated baked on polyester finish
    - Color selected by architect and approved by LPS OMC and LPS PM
- PVC Jacketing
  - UV resistant PVC
  - 30 mil thick
  - Factory cut and curled to fit O.D. of insulated pipe

- Solvent weld adhesive for sealing joints and seams

- Rubber/Tedlar Jacketing
  - ASTM-D-1424-63, ASTM-D-774, and ASTM-E-84
  - Manufactured from a combination of heavy fiberglass fabric coated with Hypalon Rubber, fully cured and laminated to a Tedlar facing
  - Jacketing required to be vapor barrier and laminated to a corrosion resistant aluminized mylar
  - 0.010" thick minimum
  - UL Class I rated, acid and alkali resistant, and be both washable and paintable
- Cloth Jacketing Material
  - Not less than 8 oz. per square yard with adhesives, cement and sealer as recommended by insulation manufacturer for the intended application
    - PVC premolded fitting covers shall not be provided

- Plumbing Piping System Insulation
  - Insulation not required on
    - Chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, fire protection piping, and pre-insulated equipment
  - Cold Piping
    - Applications
      - Potable and non-potable cold water piping
      - Potable chilled water piping
      - Interior above-ground horizontal storm water piping including elbow up & down
      - Roof drain bowls and roof drain leader to horizontal piping
      - Overflow roof drain bowls and first 10 feet of overflow piping
    - Requirements
      - Above Ground Inside Building Fiberglass
      - ½ inch thickness
  - Hot Piping
    - Applications
      - Potable hot water and tempered piping
      - Potable hot water and tempered recirculating piping
    - Requirements

- Fiberglass
  - 1/2 inch for runouts to individual fixtures 12'-0" or less in length
  - 1 inch thick for pipe sizes up to and including 2 inch
  - 1 1/2 inch thick for pipe sizes over 2 inches
- Below Ground Runouts to Individual Fixtures - Flexible Elastomeric
  - 1/2 inch thickness for pipe sizes up to 2 inches
- Sound Insulation
  - Show on drawings
  - 2 inch flexible fiberglass/vinyl sound insulation
  - Install with foil tape at all seams
  - Provide plastic wire ties every 18 inches around piping to fully fasten insulation to piping
  - Obtain a copy of manufacturer's installation requirements, keep copy on site, and follow all instructions

- HVAC Piping System Insulation
  - Review general industry standard fiberglass verses cellular glass with LPS OMC and LPS PM cost benefit for
    - Moisture resistance
    - Consider for exterior, underground, or high humidity applications
    - Verify local installers are familiar with the product, and any cost implications
  - Insulation not required on
    - Insulation may be omitted inside of cabinet unit heaters, convectors and fan coils for hot piping
    - Cold piping insulation inside fan coil unit cabinet may be omitted provided piping is located over drain pan
    - Hot and cold piping routed inside air handler units REQUIRED to be insulated
    - Insulation on strainers in heating water strainers operating below 200 degrees F.
  - Heat Traced Piping
    - Applications
      - Piping exposed to freezing which is specified with heat cable
    - Requirements
      - Fiberglass
        - 1 1/2 inch thick for pipe sizes up to and including 2 inch
        - 2 inch thick for pipe sizes over 2 inches

- Above Ground, Exterior - Cellular Glass
  - 1 1/2 inches thick for pipe sizes up to and including 2 inch
  - 2 inches thick for pipe sizes over 2 inches

- Sub-Freezing Piping (0 to 39 deg. F (-18 to 4 degrees C)
  - Applications
    - Refrigerant suction lines between evaporators and compressors
  - Requirements
    - Fiberglass
      - 2 inches thick for pipe sizes up to and including 1 inch
      - 2-1/2 inch thick for pipe sizes over 1 inch
    - Above Ground Exterior - Cellular Glass
      - 1 1/2 inch thick for pipe sizes up to and including 1 inch
      - 2 inch thick for pipe sizes over 1 inch
    - Pre-Insulated Soft Copper Refrigerant Line Sets - Flexible Elastomeric
      - 1 inch thickness for pipe sizes up to and including 2 inches
- Cold Piping (40 degrees F (4.4 degrees C) to ambient)
  - Applications
    - Chilled water supply and return piping
    - Cold condensate drain piping
    - Condenser water supply and return piping when used with plate and frame or cooling coil applications
  - Requirements
    - Fiberglass
      - 1/2 inch thick for runouts to individual units up to 2 inches in size and less than 12 feet-0 inches in length
      - 1 inch thick for pipe sizes up to and including 8 inch
      - 1-1/2 inch thick for pipe sizes over 8 inches
    - Exterior, Above Ground - Cellular Glass
      - 1/2 inch thick for run-outs to individual units up to 2 inches in size and less than 12 foot-0 inches in length
      - 1 inch thick for pipe sizes up to and including 2 inch
      - 2 inch thick for pipe sizes over 2 inches.
    - Below Ground - Flexible Elastomeric
      - 1/2 inch thickness for pipe sizes up to 2 inches

- Dual Temperature Piping (40 degrees to 200 degrees F (5 to 90 degrees C))
  - Applications
    - Hot and chilled water changeover supply and return piping
  - Requirements
    - Insulate each piping system specified above with the heating system types and thicknesses of insulation specified for heating system piping, and with the methods required for cold piping
- Heating System Piping (to 200 degrees F (90 degrees C))
  - Applications
    - Hot water supply and return piping
    - Hot gas refrigerant piping (interior, exposed, less than 7feet-6inches above floor)
    - Hot gas bypass refrigerant piping (interior, exposed, less than 7feet-6inches above floor)
    - Heat recovery water
    - Heat reclaim coil header
    - Boiler feedwater piping
    - Blowdown piping
  - Requirements
    - Fiberglass
      - ½ inch thick for runouts to individual units up to 2 inches in size and less than 12 feet-0 inches in length
      - 1 1/2 inches thick for pipe sizes up to and including 8 inch
      - 2 inch thick for pipe over 8 inches
    - Above Ground Exterior - Cellular Glass
      - 2 inches thick for pipe sizes up to and including 8 inches
      - 2-1/2 inch thick for pipe sizes 8"
    - Underground Piping to Individual Terminal Units – Flexible Elastomeric
      - ½ inch thick up to 2 inch pipe size
- High Temperature, Low Pressure Piping (200 to 250 degrees F (90 to 120 degrees C))
  - Applications
    - HVAC high temperature (200 to 250 degrees) hot water supply and return piping
  - Requirements

- Fiberglass
  - 1 inch thick for runouts to individual units up to 2 inches in size and less than 12 feet in length
  - 1 1/2 inch thick for pipe sizes up to and including 2 inch
  - 2 inch thick for pipe sizes 2-1/2 inches through 4 inches
  - 3 1/2 inches thick for pipe sizes over 4 inches
- Above Ground, Exterior - Cellular Glass
  - 2 1/2 inches thick for pipe sizes up to and including 2 inch
  - 3 inch thick for pipe size 2-1/2 inches through 6 inches
  - 5 inches thick for pipe sizes over 8 inches

- High Temperature, Medium and High Pressure Piping (250 to 350 degrees F (120 to 175 degrees C)
  - Applications
    - High temperature (250 degrees to 350 degrees) hot water supply and return piping
    - Medium and High pressure (16 to 125 psig) steam piping
  - Requirements
    - Fiberglass
      - 2 inches thick for pipe sizes up to and including 1 inch
      - 2 1/2 inches thick for pipe sizes 1-1/4 inch through 4 inches
      - 3 1/2 inches thick for pipe sizes over 4 inches
    - Exterior, Above Ground - Cellular Glass
      - 3 inches thick for pipe sizes up to and including 1 inch
      - 4 inches thick for pipe size 1-1/4 inch through 4 inches
      - 5 inches thick for pipe sizes over 4 inches
- High Temperature Piping (to 1200 degrees F (649 degrees C)
  - Applications
    - Exhaust Piping fittings and silencers for emergency generators
    - Exhaust Piping fittings and silencers for engine driven fire pumps
  - Requirements
    - Calcium Silicate 4 inches thick.
    - Fiberglass is PROHIBITED
- High Temperature Piping (to 2000 degrees F (1093 degrees C))
  - Applications

- Exhaust Piping fittings and silencers for emergency generators
- Exhaust Piping fittings and silencers for engine driven fire pumps

- Requirements
  - Thickness dependent on temperature and design of insulating system
  - Concealed Piping
    - Flexible thermal Ceramic
    - 6 pcf
  - Exposed Piping
    - Rigid Thermal Ceramic System
  - Calcium Silicate is PROHIBITTED

- Installation of Piping Insulation
  - Install insulation on pipe systems subsequent to installation of heat tracing, testing, and acceptance of tests
  - Maintain integrity of vapor-barrier jackets on cold pipe insulation, and protect to prevent puncture or other damage.
  - Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated
  - On flexible elastomeric pipe insulation apply two (2) coats of manufacturer's approved U.V. resistant finish.

Ductwork Insulation

- Materials
  - Coordinate exterior ductwork insulation spec with details on drawings
  - Consider cost, durability, moisture resistance, and appearance with LPS OMC and LPS PM
    - Metal jacket is best, and most expensive
    - Armaflex finish needs repainting every 3-5 years and cannot be applied below 50 degrees F
  - Rigid Fiberglass Ductwork Insulation
    - ASTM C 612, Class 1, 450 degrees F temperature limit
    - Density of 3 pcf
    - "K" value shall be maximum 0.23 at 75 degrees F. mean temperature
    - Facing of 7 mil, foil-reinforced with glass mesh and laminated to 40 lb kraft
  - Round Surface Semi-Rigid Fiberglass Blanket Insulation
    - ATSM C 612, Class 1, 450 degrees F temperature limit
    - 2.5 PCF density

- "K" value of .25 max at 75 degrees F mean temp
- Foil-scrim- k raft facing
  - Orientation of fibers shall be perpendicular to facing to facilitate application on round surfaces

- Flexible Fiberglass Ductwork Insulation
  - ASTM C 553, Type I
  - 3/4 lbs per cu. ft. density
  - "K" value shall be maximum 0.25 at 75 degrees F. mean temperature
  - 250 degrees F temperature limit
  - Vapor transmission rating shall not exceed 0.02 perms
  - Facing of .7 mil foil reinforced with glass mesh and laminated to 40 lb kraft
- Flexible closed cell elastomeric insulation
  - ASTM C534, Type I
  - "K" value shall be a maximum 0.27 at 75 degrees F mean temp
  - 220 degrees F Temperature limit
  - Water vapor permeability rating of 0.10 perm inches or less
- Jackets for Ductwork Insulation
  - ASTM C 921
    - Type I for ductwork with temperatures below ambient
    - Type II for ductwork with temperatures above ambient.
  - Aluminum Jacketing
    - T3003 (or T/5005) H14 to H19 aluminum alloy with 3/16 inch corrugations
    - Factory attached 1 mil thick polyethylene moisture barrier continuously laminated across the full width of the jacketing
    - 0.016 inches thick minimum
    - Matching factory fabricated covers for 90 degrees and 45 degrees elbows, tee fittings, branch fittings, reducers and other fittings necessary to make the covering system complete, waterproof and weatherproof
    - Optional jacketing color coated baked on polyester finish
      - Color selected by architect and approved by LPS OMC and LPS PM
  - Rubber/Tedlar Jacketing
    - ASTM-D-1424-63, ASTM-D-774, and ASTM-E-84
    - Manufactured from a combination of heavy fiberglass fabric coated with Hypalon Rubber, fully cured and laminated to a Tedlar facing

- Required to be vapor barrier and shall be laminated to a corrosion resistant aluminized mylar
- 0.010" thick minimum
- UL Class I rated, acid and alkali resistant, and be both washable and paintable
- Factory fabricated aluminum fitting covers with mil-polyethylene vapor barrier for all elbows, tees, and other fittings.

- Flexible closed cell elastomeric insulation shall be coated with two coats Armstrong WB Armaflex Finish or equal

- Ductwork System Insulation
  - Insulation not required on
    - Fibrous glass ductwork, or lined ductwork
  - Application
    - Outdoor air intake ductwork and plenums between air entrance and fan inlet or HVAC unit inlet
    - Mixed air ductwork and plenums between air entrance and fan inlet or HVAC unit inlet
    - HVAC supply ductwork between fan discharge, or HVAC unit discharge, and room terminal outlet unless ductwork is specified to be lined
    - HVAC return ductwork in unconditioned spaces or exterior; except omit insulation when ductwork is specified to be lined
    - HVAC plenums and unit housings not pre-insulated at factory or lined
    - Rigid oval or round supply air ductwork

CONTINUED ON NEXT PAGE

- Requirements

| APPLICATION | TYPE, THICKNESS | | |
|---|---|---|---|
| | RIGID/ FIBERGLASS (see notes 1&2) | FLEXIBLE FIBERGLASS | FLEXIBLE ELASTOMERIC** |
| Interior; concealed; cold, hot or dual temperature duct | 1" min. up to 2" as required to cover joints & reinforcements | 1-1/2" | 1" |
| In humid/humidified environments, the flanges must be covered to prevent condensation | | | |
| Interior; exposed within conditioned finished spaces; cold, hot, or dual temperature duct | None<br>1" min. up to 2" as required to cover joints & reinforcements | None Not Allowed except for budget considerations | None<br>1" min. up to 2" as required to cover joints & reinforcements. Provide white finish coat. |
| [Duct Mate Fittings require 2". Coordinate with ductwork specification | | | |
| Interior; exposed within mechanical, electrical, storage, or other service areas; cold, hot, or dual temperature duct | 1" min. up to 2" as required to cover joints and reinforcements | Not Allowed except for budget considerations | 1" min. up to 2" as required to cover joints and reinforcements with white finish. Provide white finish coat. |
| Duct Mate Fittings require 2". Coordinate with ductwork specification | | | |
| Exterior; hot or dual temperature duct, all return duct | Not Allowed | Not Allowed | 2" with metal jacket OR with weather protective finish OR with rubber/Tedlar jacket |
| Unconditioned Attic; hot, cold, dual temperature, or return duct | 1-1/2" | 2" | 1-1/2" |
| Unconditioned Crawl Space; cold duct, returns serving exclusively cooling systems | 1" | 1-1/2" | 1" |
| Unconditioned Crawl Space; hot, dual temperature or return duct | 1-1/2" | 2" | 1-1/2" |
| Use semi-rigid fiberglass insulation for round or flat oval duct | | | |

- Installation of Ductwork Insulation
  - Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage
  - Avoid the use of staples on vapor barrier jackets
  - Seal vapor barrier penetrations with vapor barrier tape recommended by manufacturer
  - Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated
  - Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed
  - Except for oven and hood exhaust duct insulation, install corner angles on all external corners of insulation on ductwork in exposed finished spaces before covering with jacketing
  - Repair damaged sections of existing mechanical insulation, both previously damaged or damaged during this construction period
  - Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units

Equipment Insulation

- Materials
  - Rigid Fiberglass Equipment Insulation
    - ASTM C 612, Class 2
    - "K" factor shall be maximum 0.28 at 200 degrees F. mean temperature
    - 3.0 lb. density
    - 850 degrees F temperature limit
  - Flexible Fiberglass Equipment Insulation
    - ASTM C 553, Type I
    - "K" factor shall be maximum 0.45 at 250 degrees F. mean temperature
    - 850 degrees F temperature limit
  - Calcium Silicate Equipment Insulation
    - ASTM C 533, Type I, Block
    - "K" factor shall be maximum 0.87 at 1000 degrees F. mean temperature
    - Compression strength 200 psi for 5 percent compression
    - Transverse strength 60 psi
  - Flexible closed cell elastomeric insulation
    - ASTM C534, Type I
    - "K" valve shall be a maximum of 0.27 at 75 degrees F mean temp

- 220 degrees F temperature limit
- Water vapor permeability of 0.10 perm inches or less

▪ Jacketing Material for Equipment Insulation

- Pre- sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket

o Equipment Insulation

▪ Cold Equipment (Below Ambient Temperature)

- Applications
  - o Refrigeration equipment, including chillers, tanks and pumps
    - ▪ Include any cold surfaces not factory insulated
  - o Condensate pans under chilled equipment
  - o Cold water storage tanks
  - o Cold and chilled water pumps
  - o Pneumatic water tanks (existing, only)
  - o Air separators
- Requirements
  - o Rigid Fiberglass
    - ▪ 1 inch thick for surfaces above 35 degrees F (2 degrees C)
    - ▪ 1 1/2 inch thick for surfaces 35 degrees F (2 degrees C) and lower
  - o Flexible Elastomeric Sheet
    - ▪ ¾ inch thickness for surface temperatures above 35 degrees F (2 degrees C)
    - ▪ 1 inch thickness for surface temperatures below 35 degrees F (2 degrees C)

▪ Hot Equipment (Above Ambient Temperature)

- Applications
  - o Boilers (not pre-insulated at factory)
  - o Hot water storage tanks
  - o Water heaters (not pre-insulated at factory)
  - o Heat exchangers
  - o Condensate receivers
  - o Hot water pumps operating over 200 degrees
  - o Condensate pumps
  - o Flash tanks

- Air separators
- Blow down separators
- Induced draft fan scrolls
- Feedwater storage tanks
- Absorption chiller hot surfaces (not pre-insulated at factory)

- Requirements
  - Fiberglass
    - 2 inch thick
    - 3 inch thick for low- pressure boilers
    - PROHIBITED for equipment above 450 degrees F (232 degrees C)
  - Calcium Silicate
    - 3 inch thick
    - 4 inch thick for diesel exhaust mufflers
    - 4-1/2 inches thick for low-pressure boilers
- Insulation of breechings and stacks
  - Breechings between heating equipment outlet and stack or chimney connection, except for double wall or factory insulated breechings
  - Stacks from bottom to top except for factory insulated stacks
  - Insulate with Calcium Silicate, 4 inches thick (2 layers of 2 inch thickness)

- Installation of Equipment Insulation
  - Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage
  - Do not apply insulation to equipment, mufflers, breechings, or stacks while hot
  - Do not insulate hot equipment ASME stamp and manufacturer's nameplate
  - Provide neatly beveled edge at interruptions of insulation.
  - Cold equipment requiring access
    - Provide removable section of insulation, fabricated from flexible elastomeric insulation, adhered to an aluminum jacket, and joined with velcro strips around entire perimeter
    - Reinforce removable section and adjoining insulation at attachment points
    - Provided for all equipment requiring periodic inspection, access or maintenance
      - Chilled water pump bodies
      - Strainer basket access
      - Heat exchanger (including chillers) tube access

- Handhold/cleanout covers

- Hot equipment requiring access
  - Provide removable section of insulation, either
    - Fabricated from rigid fiberglass insulation board, adhered to an aluminum jacket, and fastened to the equipment with stainless steel bands
    - Pre-fabricated, canvas jacketed, lace-up insulation blankets
  - Provide removable insulation for hot equipment requiring access with accessible components over 100 square inches or any component operating over 200 degrees including
    - Heat exchanger tube access.
    - Handhole/manhole/cleanout access.
- Protect outdoor insulation from weather by
  - Installation of aluminum jacketing, as recommended by manufacturer
  - On flexible elastomeric insulation, apply two (2) coats of manufacturer's approved U.V. resistant finish

Sound Lagging Insulation

- Approved Manufacturers
  - Certainteed
  - Owens-Corning
  - Soundseal
  - Vibro-Acoustics
  - Schuller
- Flexible Fiberglass & Vinyl Sound Insulation
  - 1.0 PSF, .090 inch thick mylar feed vinyl loaded barrier, tested to 400psi tensile strength
  - Absorber material, foil covered fiberglass laminated on vinyl barrier, .40 PSF, 2 inch nominal thickness insulating value of R-8.0
  - Assembly flame/smoke index of 12.5/19.5 tested per Class A ASTME-84
  - Assembly sound tested per ASTME-90 for a 5Tlof 30 or greater
  - Rated for temperature between -20 degrees F & 350 degrees F

| **SOUND TRANSMISSION LOSS (dB) FREQUENCY (Hz)** | | | | | | |
|---|---|---|---|---|---|---|
| PRODUCT | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| B-10 LAG 1 QFA-9 | 19 | 20 | 23 | 33 | 44 | 53 |

- 4” matching sound lagging foil tape
- Insulation for application over duct, piping & equipment.

# SECTION 23 08 00 - MECHANICAL COMMISSIONING

PART 1 - GENERAL

**NOTE**: This section applies to projects that include commissioning as part of the scope of work, to be determined by the **LPS Operations, Maintenance and Construction (OMC) Department**.

1.1 DESCRIPTION:

A. Purpose:

1. Verify operation and functional performance of central mechanical HVAC systems, controls and electrical systems for compliance with "Design Intent", as defined by the Contract Documents.

2. Document Mechanical and Electrical system test and inspections.

3. Verify application of operation and maintenance manuals, as-build (record) documents, spare parts lighting, special tools, controls and other items as may be specified herein for support of Mechanical and Electrical systems and equipment.

4. Provide indirect support of the training of personnel for operation and maintenance of Mechanical and Electrical equipment and systems.

B. General:

1. Furnish labor and material to accomplish complete mechanical and electrical system commissioning as specified herein. Complete interim commissioning of HVAC systems during initial season operation.

C. Job Conditions: The commissioning contractor shall become familiar with the contract documents, all addenda, and change orders issued for this project prior to commencing commissioning work.

1.2 QUALITY ASSURANCE:

A. Reference: ASHRAE Guideline 1P, "Guideline for Commissioning of HVAC System.

B. Qualifications: The "Commissioning Authority" shall be defined as a company or agency of experienced personnel, qualified to plan & carry out the overall commissioning progress. The Commissioning Authority shall submit for owner review, an outline of the organization's personnel qualification resources, commissioning, documentation process & commissioning plan specifically prepared for this project.

1.3 DOCUMENTATION:

A. The Commissioning Authority shall obtain the following:

1. Project plans and specification (contract documents), authorized revisions, shop drawings and submittals (approved, Test and Balance report, equipment start-up and certification reports, operation and maintenance manuals, etc.

2. Records of required code authority inspections, contractor test inspections, documentation sign-offs, etc.

1.4 SUBMITTALS:

A. Commissioning Authority will submit the name of the commissioning project manager approval prior to starting the commissioning process.

1. Commissioning Plan (describe extent and delivery schedule.)

2. Commissioning Outline Plan (describe extent of plan, expected duration of observations, personnel involved, schedule, etc.)

3. Tool List: provide a detailed list of the tools required for the commissioning process.

1.5 RESPONSIBILITIES OF OTHERS: Applicable specification sections outline trade responsibilities during the commissioning process.

A. General Contractor:

The General Contractor shall verify completeness of the building envelope, perimeter and interior items, which effect proper operation, and control of HVAC equipment and systems.

The General Contractor will assure participation and cooperation of specialty contractors (Mechanical, TAB, building automation system, etc.) under his jurisdiction as required for the commissioning process.

B. Specialty Contractors:

Individual mechanical and electrical sub - will be responsible for providing labor, material, equipment, etc., required within the scope of this specialty to facilitate the commissioning process. The listed Sub-Contractor will perform tests and verification procedures required by the commissioning process when requested by the Commissioning Authority and directed by the General Contractor.

C. Owner/Operator:

1. Owner/Operator may schedule personnel to participate in commissioning process.

2. Owner/Operator will advise the Commissioning Authority regarding changes in building occupancy, usage, or functional requirements.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION:

A. Instrumentation will be provided by agency performing prior tests. Instruments will be operated by individual agency requested by the Commissioning Authority, as specified elsewhere herein.

PART 3 - EXECUTION

3.1 GENERAL:

A. Commissioning Authority will participate in the final construction phase of the project to assure compliance with specific Commissioning requirements.

3.2 PROCEDURE:

A. Attend construction meeting and establish requirements for the Commissioning process throughout construction phase.

B. Prepare and submit to the Owners representative (name)_____within _____ weeks after contract award a Commissioning plan which shall outline:

1. Responsibility of each trade affected by Commissioning as required by appropriate section of this specification.

2. Requirement for documentation as listed elsewhere herein.

3. Requirements for documentation of tests and inspections required by code authorities.

4. Requirements for the Commissioning program during specified operational seasons part and full loads as further delineated in Subsection 3.3.

C. Periodically attend construction and coordination meetings.

3.3 MECHANICAL SYSTEMS COMMISSIONING:

A. Mechanical System Commissioning shall begin after HVAC equipment and systems, along with related equipment; systems, structures and areas are complete.

B. Verify TAB readings, such as:

1. Supply and return air CFM quantities.
2. Fan performance
3. Hydronic performances
4. Branch duct readings
5. Refrigeration side performance
6. Chiller performance
7. Cooling tower performance
8. Boiler performance

C. Verify calibration of thermostats and related controls, such as:

1. VAV boxes
2. Multi-zone damper settings and operators
3. Valve positions
4. Damper position

D. Verify readings of remote data and control systems, such as:

1. Temperature
2. Air flow
3. Damper positions
4. Water pressure
5. Water temperatures

E. Verify operation of system modes, such as economy cycle, smoke removal and in specific:

1. Damper and fan operation
2. Smoke detector response
3. Zone response

F. Verify that total HVAC system is performing to provide conditions as outlined in the contract documents, including seasonal, part and full load conditions.

The following commissioning checklists are provided to illustrate the minimum information, which should be included in the commissioning checklist final report.

1. PRIOR TO FUNCTIONAL PERFORMANCE TEST:

a. Chiller has been set in place and piped - hydrostatically leak tested.
b. Factory start-up and check out complete with report submitted.
c. Chiller safety and protection devices tested, report submitted.
d. The following check lists completed and submitted:
    1) Chilled water/condenser water pumps.
    2) Cooling tower.
    3) Controls and instrumentation checklist.
    4) Test and Balance Report submitted.
    5) Chemical treatment report.
e. Personnel present during demonstration:
    1) General Contractor, Mechanical, Electrical, and Controls Contractor.
    2) Commissioning authority.
    3) Owner's representative.
f. Functional Performance Test: Contractor shall demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows:
    1) Time of day start-up program initiates chiller start.
    2) Start condenser water pump, establish flow, and activate chiller proof of flow switch.
    3) Start chilled water pump, establish flow, and activate chiller proof of flow switch.
    4) Control system energizes chiller start sequence.
    5) Chiller senses chilled water temperature above set point, chiller control system activates start.
    6) Verify functioning of "soft start" sequence, record motor amperage as a time function.
    7) Verify cooling tower controls function, refer to checklist.
    8) Chiller load to be calculated by controls system, provide trend log of load imposed.
    9) Shut-off air handler to remove load on chilled water system.
    10) Verify chiller shut down sequence after load is removed.
    11) Re-start air handler within 2 minutes of chiller shut down. Verify condenser and chilled water pump, cooling tower controls sequence.

2. Results:

a. The Commissioning Authority shall report results obtained in 3 above.
    1) If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.
b. Reports:
    1) Submit reports of Functional Performance Test above to Owner’s representative.

## COMMISSIONING CHECKLIST - PUMPS

1. Prior to Functional Performance Test
    a. Pumps in place, grouted, vibration isolation devices functional, pump alignment, and rotation verified.
    b. Power available with motor protection, safeties, control system contractors, and interlocks functional.
    c. Piping system pressure tested, cleaned, chemical water treatment complete and report submitted. Piping systems filled and chemically treated (where applicable).
    d. Pressure and temperature gauges installed and functional.
    e. Water balance complete with design maximum flow, pressures obtained, and report submitted

2. Personnel present during functional performance test:
   a. General Contractor, Mechanical Contractor, Controls Contractor, Electrical Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional performance test: Contractor shall demonstrate operation of pumps as per specification including the following:
   a. Activate pump start using control system command.
   b. Verify pressure drop across strainer, verify strainer is clean. Verify pump inlet/outlet pressure reading, compare to Test and Balance Report, pump design conditions, and pump manufacturer's performance data. Operate pump at shut-off, 50% and 100% flow. Plot test readings on pump curve. Verify specified flow is obtained.
   c. Verify motor amperage each phase and voltage phase to phase and phase to ground.
   d. Check and report unusual vibration, noise, etc.

4. Results:
   a. The Commissioning Authority shall report results obtained in item 3 above.
   b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:
   a. Submit reports of functional performance test item 3 above to owner's representative.

## COMMISSIONING CHECKLIST – COOLING TOWER/CHEMICAL TREATMENT

1. Prior to Functional Performance Test:
   a. Cooling tower is in place, piped; motor and fan drive adjusted, make-up valve and water supply piped.
   b. Power is available with motor protection safeties and disconnect at tower operational. Controls systems, contractor's interlocks functional. Motor and fan rotation checked.
   c. Tower basin is filled, cleaned, and water treatment system functional with report from treatment contractor submitted.
   d. Water balance is complete with design flow verified and water distribution headers balanced.
   e. Fan lubricated and blade pitch adjusted.

2. Personnel present during demonstrations:
   a. General Contractor, Mechanical, Electrical, and Controls Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: The Mechanical Contractor shall Functionally Performance Test the operation of the cooling tower as per specification and the following:
   a. Activate cooling tower fan start using control system command. This should first start condenser water pump, establish flow, and delay fan start for 30 seconds to equalize flow in distribution basin and sump. Start fan after times delay.
   b. After chiller start-up, control system should modulate bypass valve and two-speed fan motor to maintain $75^{o}$F return water temperature to chiller. Observe and record functioning of bypass valve under varying loads.
   c. Verify interlock with chiller; cooling tower fan should operate concurrently when chiller is energized.
   d. Verify make-up water float valve is functioning. Activate chemical treatment feed valve; verify make-up of chemical treatment system, pump, and controls.
   e. Sample cooling tower water and test for suspended solids, record solids meter reading for each sample to verify accuracy.
   f. Record reading on tower make-up water supply meter, compare to chiller load summation of ton-hours. Make-up water use would be 2 gallons per ton hour. Report variance. Record amount of

chemical used, forward to water treatment contractor for review and approval based upon amount of make-up water used.

4. Results:
   a. The Commissioning Authority shall report results obtained in item 3 above.
   b. If specified equipment performance is not verified, Commission Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:
   a. Submit reports of Functional Performance Test item 3 above to engineer.

## COMMISSIONING CHECKLIST – HOT WATER BOILERS

1. Prior to functional performance test:
   a. Boiler has been set in place and piped - hydrostatically leak tested.
   b. Factory start-up and check out complete with report submitted.
   c. Boiler safety and protection devices tested, report submitted.

2. The following checklists completed and submitted:
   a. Boiler water.
   b. Primary and secondary water pumps.
   c. Controls and instrumentation checklist
   d. Test and Balance Report submitted.
   e. Chemical treatment report.
   f. Natural gas and oil delivery systems.
   g. Boiler flues.

3. Personnel present during demonstration:
   a. General Contractor, Mechanical, Electrical, and Controls Contractor.
   b. Commissioning authority.
   c. Owner's representative.

4. Functional Performance Test: Contractor shall demonstrate operation of hot water boiler system as per specifications including the following: Start building air handlers to provide load for boiler. Activate controls system boiler start sequence as follows:
   a. Time of day start-up program initiates boiler start.
   b. Start boiler water pump, establish flow, and activate boiler proof of flow switch.
   c. Start boiler internal circulation pump.
   d. Verify low water cutoff safety and water makeup supply.
   e. Verify operation of temperature and pressure gauges. Operate high-pressure limit control.
   f. Verify operation of water relief valves.
   g. Verify operation of temperature controls to operate burner.
   h. Verify burner operation on natural gas including a 4:1 turn down modulation and gas trans safety.
   i. Verify burner operation on #2 fuel oil including operation of integral fuel oil pump.
   j. Verify operation of forced draft blower and combustion air modulating damper.
   k. Inspect boiler control panel for operation of controls and indicating lights.
   l. Verify ignition timing for pre-combustion pure, and post combustion purges and flame failure shut down.
   m. Verify chemical treatment report.
   n. Provide boiler stack analysis to verify full load and part load thermal efficiency.

5. Results:
   a. The (Commissioning Authority) shall report results obtained in 3 above.
   b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.
6. Reports:
   a. Submit reports of Functional Performance Test above to Owner's representative.

## COMMISSIONING CHECKLIST – VAV DEVICES AND DUCTWORK

1. Prior to Functional Performance Test:
   a. All VAV boxes are in place, ducted, connected to controls system, heating boxes connected to electrical circuits with local disconnects mounted.
   b. Ductwork complete, as-built shop drawings submitted, duct pressure and leakage test complete.
   c. Duct static pressure sensor installed, calibrated and transmitting 4-20 MA signal to fan speed controller. DDC controls system operational with input/output from each VAV box and thermostat verified, local controller functional and monitoring CRT functional.
   d. Smoke/fire dampers installed as required with access, verify status as to open/closed position.
   e. Test and balance operation is complete including each VAV box calibrated for maximum/minimum flow settings, low pressure duct and devices balanced at maximum flow conditions, heating VAV boxes fan speed setting/air flow adjusted.

2. Personnel present during demonstration:
   a. General Contractor and Mechanical, Controls and Electrical Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: Contractor shall demonstrate operation of VAV boxes as per specifications including the following:
   a. Cooling/heating VAV boxes: With system as described above, perform all cooling only tests at noted. In addition, for space heating requirement demonstrate the following:
      1) VAV box response to room temperature set point adjustment at local controller and CRT. Changes to be 78$^{o}$F to 68$^{o}$F, 72$^{o}$F and 82$^{o}$F.
         a) Check damper maximum/minimum flow settings.
         b) Verify damper actuator response to control input changes and rate of response. Record room temperature change, rate of change and overshoot/undershoot of desired temperature.
   b. VAV box response to sensor call for heating via set point adjustment, local controller and CRT changes. Changes to be warm up from 55$^{o}$F to 68$^{o}$F, from 68$^{o}$F to 74$^{o}$F. Verify cooling damper closes to minimum position, fan energized to circulate air, and upon further drop in space temperature (T-stat adjustment acceptable), verify hot water reheat activation, deactivation, and shut off on loss of air flow. Loss of airflow to be demonstrated by interrupting interlock or manual air vane flow sensor adjustment. Record room temperature change, rate of change and overshoot/undershoot of set point temperature.

4. Results:
   a. The Commissioning Authority shall report results obtained in 3 above.
   b. If specified equipment performance is not verified, the Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

6. Submit reports of Functional Performance Test item 3 above to the owner's representative.

## COMMISSIONING CHECKLIST – AIR HANDLING UNITS

1. Prior to Functional Performance Test:
   a. Verify unit is properly installed, securely fastened to floor with vibration isolators, access doors are operable and sealed, dampers and casing undamaged, insulation, and drain pan and interior are not damaged. Check and verify condensate drainage is unobstructed.
   b. Verify power available to unit disconnect and control panel.
   c. Verify chilled water piping or DX piping (where applicable) is connected to cooling coils, pressure tested, cleaned, and chemical treatment performed with report submitted.

d. Verify control valves and damper actuators are installed, control power is energized and valves/dampers operable.
e. Verify variable speed supply fan controller is energized with control power source available (if applicable).
f. Verify shipping blocks on supply fan isolation rails are removed, fan drive and motor adjusted, check rotation.
g. Verify return fan drive and motor adjusted, check rotation.
h. Verify construction start-up T & B filters removed and replaced with new filters. During testing, completely blanket filters with filter media to simulate 0.5 in W.C. pressure drop (1/2 dirty filters).
i. Test and Balance Report submitted.

2. Personnel present during demonstration:
   a. General Contractor and Mechanical, Electrical, and Controls Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: Contractor shall verify operation of air handling unit (AHUS) as per specification including the following:
   a. Activate AHUS using control system command.
   b. The following sequence of control shall be verified: Start-up
      1) Minimum and economizer outside air damper closed.
      2) Return air damper open.
      3) Relief air damper closed.
      4) Low temperature cutout allows start of fan if temperature inside unit is above 45$^{o}$F.
      5) Multizone AHUS zone dampers motors are installed and operational.
   c. Normal Day-time operation - ambient temperature above specified economizer changeover.
      1) Minimum outside air damper open.
      2) Economizer outside air damper closed.
      3) Return air damper open.
      4) Relief air damper closed.
      5) Fan multizone controller receiving signal from temperature sensor.
      6) Chilled water control valves modulate to maintain 55$^{o}$F leaving air temperature.
   d. Economizer cycle outside air temperature less than specified economizer changeover.
      1) Minimum outside air damper open
      2) Economizer outside air damper modulated to maintain 60$^{o}$F supply air.
      3) Relief air damper modulates to relief economizer supply air.
      4) Chiller and chiller pumps/cooling tower and pumps off.
      5) Fan multizone controller receiving signal from temperature sensor.
   e. Nighttime shut down (where applicable).
      1) Outside air dampers closed.
      2) Return air damper open.
      3) Relief air damper closed.
      4) Ambient conditions below 45$^{o}$F, activate unit-heating coil to maintain 50$^{o}$F inside building.
   f. Verify VAV fan inlet vain controller calibration and maintenance of duct static pressure 1.5 in w.c. 0.2 in during 20% to 100% of design air flow.
   g. Verify chilled water coil control valves sequence to operate 1/3 coil valve to full open, then 2/3 coil valve to full open and the reverse sequence under varying load conditions.
   h. Verify unit shut down during fire event initiated by smoke/heat sensors, or day room smoke purge activation.
   i. Verify airflow balance, outside air/return air; during variable unit air flow conditions.

4. Results:
   a. The Commissioning Authority shall report results obtained in 3 above.
   b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

a. Submit reports of Functional Performance Test item 3 above to owner's representative.

## COMMISSIONING CHECKLIST – BAS CONTROL SYSTEMS

1. Prior to Functional Performance Test:
   a. All control devices are in place, operable, calibrated, and communicating with local control panels and operator interface terminal communicating with local control panels and operator interface terminal (CRT).
   b. Test and verify power supplies, wiring, low voltage transformers, allowable voltage drops, and related interlocks are available and meet specifications. Continuity has been checked.
   c. Verify that control software programs have been loaded, edited and operational.
   d. Controlled devices, mechanical equipment, actuators, and sensors are complete and operable.
   e. Interrupt building power supply for 30 minutes, re-energize, verify software packages and programming remained intact and operable after interruption.

2. Personnel present during demonstration:
   a. General, Mechanical, Electrical, and Controls Contractors.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: Contractor shall verify operation of the controls system as per specification and the following:
   a. Sensing Element: Verify wall mounted sensing elements are located per plans, securely mounted on wall with protective cover. Furnish plans, securely mounted on wall with protective cover. Furnish calibrated digital thermometer 40-105$^{o}$F +0.5$^{o}$F accuracy to verify reporting temperature of each sensing element. At each sensing element compare temperature sensed vs. actual temperature. Query each sensing element from local control panel and CRT; allowable variance is 0.5$^{o}$F from digital thermometer.
   b. Follow procedure described in item a) above for all temperature-sensing device.
   c. VAV box controllers, refer to demonstration procedure in VAV section.
   d. In each VAV control zone, reset set point from 72$^{o}$F to 60$^{o}$F, and then record time to achieve set point (as climatic conditions and internal loads permit).
   e. Night setback (as climatic conditions allow): Verify heating VAV boxes operate to maintain 55$^{o}$F space temperature.
   f. Morning warm-up cycle: Verify warm-up time, trend logging function, and reset of warm-up time at different ambient conditions, i.e. 50$^{o}$F ambient and 30$^{o}$F.
   g. Air Handling Unit: Refer to demonstration procedure in applicable section. At CRT, reset leaving air temperature set point, log response of multizone AHU's zone control valves, space temperatures, VAV box reactions, and system flow in system.
   h. Chiller/cooling tower/pumps: Log chiller load and leaving water temperature as a result of resetting chilled water set point from 45$^{o}$F to 50$^{o}$F.
   i. For all controls Functional Performance Test, prepare report in format as follows:
      1) Binary points (per specified points list)

| Verify: | YES | NO |
|---|---|---|
| Command issued | ___ | ___ |
| Command accepted | ___ | ___ |
| Command executed | ___ | ___ |
| Controlled device responded | ___ | ___ |
| Feedback verified response | ___ | ___ |

      2) Analog points (per specified points list):

| | INITIAL* | | FINAL* | |
|---|---|---|---|---|
| Verify: | YES | NO | STATUS | STATUS |
| Command issued | ___ | ___ | _____ | _____ |
| Command accepted | ___ | ___ | _____ | _____ |

| | | | | |
|---|---|---|---|---|
| Command executed | ___ | ___ | _____ | _____ |
| Controlled device responded | ___ | ___ | _____ | _____ |
| Feedback verified response | ___ | ___ | _____ | _____ |

*Status/readings to be reported as follows:
Control Signal, Actual system effect: Air flow, temperature, pressure, etc.

For interlocked devices, positioners, multiple points of control for each commence, list effect and response on all devices.

4. Results:
   a. The Commissioning Authority shall report results obtained in 3 above.
   b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-scheduled Functional Performance Test.

5. Reports: Submit reports of Functional Performance Test item 3 above to the Owner's Representative.

**END OF SECTION 23 08 00**

# SECTION 23 09 23 - DIRECT DIGITAL CONTROL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

***Edit paragraphs A & B for each project as applicable.***

A. The Contractor shall become aware of the Method of Procedure requirements outlined in the LPS General Conditions of the Contract and Divisions 20 through 25. Change orders will not be considered for time associated with Method of Procedure requirements.

B. General: The Control System Contractor shall provide a complete new modified control system using new control devices to replace existing devices to operate as specified. The contractor shall inspect the existing conditions prior to submitting a proposal. The existing temperature control system control devices, dampers, operators, wiring, conduit, air piping, valves, etc. not being modified and which are no longer utilized, shall be removed, and not abandoned in place.

1. All temperature control devices to be removed shall be returned to the Owner in good condition.

C. The Control Contractor will be responsible for all installation, programming, commissioning, testing and performance verification.

D. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.

E. It shall be a digital, distributed microprocessor-based system, with a pneumatic and electronic interface where required at existing pneumatic devices, only. The Control System for this project will be referred to as a Building Automation System (BAS).

F. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safeties and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable.

G. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warranty for the BAS. The Control Contractor shall be responsible for supplying and installing all necessary control devices for completing the BAS.

H. The system shall include all control device, valves, interlocks, field devices, hardware, software, automatic dampers, piping, fittings, wire, conduit, etc., as specified and required and connected so as to perform all functions and operate according to the specified sequences.

*** Edit paragraph below for applicable projects.***

I. The Contractor shall leave operable existing controls in operation until the BAS is tested and proven operative. At that point, and with concurrence from the Owner and the Engineer, the Contractor shall be responsible for removing existing controls that are no longer necessary. Start-up of the BAS system, and any installation work that requires the

interruption of the normal operation of any piece of equipment, shall be scheduled with the Owner. If the interruption of the normal operation of any piece of equipment during normal working hours is unacceptable to the Owner, then it shall be scheduled during after-hours (night or weekend).

J. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Architect/Engineer in writing. Unless approved otherwise, all products (including firmware revisions) used in this installation shall have been used in at least twelve (12) projects prior to this installation. The previous sites may be located anywhere in the U.S.A. This requirement is not intended to restrict the Contractor to the use of any outdated equipment. Therefore, all products used in this installation shall also be currently under manufacture and have available, for at least ten years after completion of the contract, a complete line of spare parts. If the above requirements are mutually exclusive, the Contractor shall include a specific statement to this effect in the Bid.

K. Refer to other Divisions 20 through 25 sections for installation of instrument wells, valve bodies and dampers in mechanical systems.

L. Provide electrical work as required, complying with requirements of Division 26 sections including, but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical connections for equipment. Work includes, but is not limited to, the following:

1. Interlock and control wiring between field-installed controls, indicating devices and unit control panels.

2. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate the temperature control system panel, motors and electrical devices requiring power which differs from the power requirements shown on the electrical drawings.

*** Verify with Electrical Consultant & Architect location of Coordination Table.***

3. Refer to other sections of Divisions 20 through 26 for mechanical/electrical coordination.

M. Control Contractor shall furnish & identify location requirements for all necessary control devices which may be installed by others including the following, but not limited to:

1. Automatic control valves.
2. Flow switches.
3. Outside, return and exhaust air dampers for the supply fan/return fan systems.
4. Modulating dampers.
5. Required wells for insertion thermostats and/or temperature sensing wells.
6. Pressure Sensors.

***Use the following paragraph for applicable projects.***

N. Each Temperature Control Contractor shall include Section 23 38 16 laboratory room pressure and fume hood controls as a part of Section 23 09 23. Each Temperature Control Contractor shall submit separate bid cost for each of the manufacturers listed in Section 23 82 00. Each T.C.C. is responsible for coordinating all labor and materials with suppliers and contractors prior to submitting bids.

1.2 QUALITY ASSURANCE:

A. Contractors Qualifications: Firms regularly engaged in installation and commissioning and servicing of digital control equipment, of types and sizes required, whose firm has been in business in similar service for not less than 5 years.

B. All work of this Section shall be fully “Year 2012 Compliant”. (See Section 23 05 00). All date- related data shall use four-digit dates. “Windowing” of dates is specifically prohibited.

C. Only those manufacturers specified are allowed to bid temperature controls. All bidders shall make available, upon the Owner's request, open-book unit-pricing of all materials and labor.

D. The system shall be installed by competent mechanics, regularly employed by the Temperature Control Contractor.

E. All bidders must have installed and completed at least two (2) direct digital temperature control jobs of similar design, size and scope using the same equipment as specified.

F. All bidders must have a local office in the area of the project site.

G. All bidders must have capabilities of doing component level repairs on all systems, including electronic systems.

H. No Field Devices shall be multiplexed to a single I/O point unless specified. Each control or sensing point shall be terminated at a unique location on the BAS panel, Slave or Dedicated Controller and be associated with a unique software point on the BAS.

I. Codes and Standards:

1. All equipment and the installation shall comply with the requirements of all applicable local and national codes including but not limited to the currently enforced edition of the Uniform Building Code, Uniform Fire Code, Uniform Electrical Code, and all applicable codes of the National Fire Protection Association including the National Electrical Code.

2. Electrical Standards: Provide electrical products, which have been tested, listed and labeled by UL and comply with NEMA standards.

3. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for electric control systems.

4. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

J. All bidders must have a minimum of one person dedicated to software generation. This person shall be located in an office local to the project site.

K. The equipment and software proposed by the supplier shall be currently in manufacture. No custom products shall be allowed unless required by the Specification. All products shall be supported by the manufacturer for a minimum of 5 years including spare parts, board repairs and software revisions.

L. The Temperature Control Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end,

each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others work.

M. It will be the responsibility of the Contractor to work in cooperation with the Owner and with all other contractors and employees rendering such assistance and so arrange his work such that the entire project will be delivered complete in the best possible condition and in the shortest time.

1.3 PROPRIETARY INFORMATION:

A. Project Documentation: All custom software, programs, code, databases, graphic files and drawings (whether hard copy or CADD based files) prepared for this system shall be the exclusive property of the Owner and shall not be reproduced or distributed without prior written permission from the Owner.

B. Reference to the Owner, any of its facilities or any of the facility automation projects shall not be used by the Manufacturer or Contractor in any promotional media, including advertisements, sale brochures, annual reports and client references or endorsements, without prior written permission from the Owner. The Owner reserves the right to restrict or refuse access to any or all of its facilities.

1.4 SUBMITTALS:

A. Submit in accordance with submittal requirements per the LPS General Conditions of the Contract and Divisions 20 through 25.

B. In addition to the requirements set forth in paragraph A above, the following shall be included in the shop drawing submittals including, but not limited to:

1. Product Data: Submit manufacturer's technical product data sheets for each control device furnished, each data sheet shall be labeled indicating its control drawing descriptor and include the following:
   a. indicating dimensions;
   b. capacities;
   c. performance characteristics;
   d. electrical characteristics;
   e. finishes of materials;
   f. commissioning, installation instructions and start-up instructions.

2. Valve, damper and well and tap schedule showing size, configuration, capacity and location of all equipment.

3. Control system drawings containing pertinent data to provide a functional operating system and a sequence of operation.
4. Detailed wiring diagrams.

5. A floor plan of each area with a detailed new conduit/wiring layout shall be included. The plan shall indicate all conduit locations within ±2' of actual installed location. All walls, doors and temperature control devices shall be accurately shown.

6. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and all control devices. Identify all control points with labeling.

7. Label each control device with setpoint or adjustable range of control. Provide a bill of materials with manufacturer's part number.

8. Indicate all required point to point electrical wiring. Clearly differentiate between portions of wiring that are existing and portions to be field-installed.

9. Provide details of faces of control panels, including controls, instruments, and labeling.

10. Include verbal description of sequence of operation and reference each device described by schematic symbol used.

11. Provide a detailed listing of all software program code written for each system.

12. Provide a point list with database input information to include a point name, address, base and span, action and other required information.

13. Provide a detailed test plan and procedure for each HVAC system and for each type of terminal unit control including valves. The test plans shall fully define reporting methods, procedure, equipment utilized, milestones for the tests, identifying the simulation programs, and personnel. The test procedures shall be developed from the test plans and shall consist of instructions for test execution and evaluation. A test report form shall be developed for each point and sequence of operation. Commissioning procedures shall be provided for each HVAC system and for each type of terminal unit control system. The procedure shall include setpoint, prop. band, integral, derivative, mode constraints input, output settings, tuning procedures., etc.

C. Submit manufacturer's installation instructions.

D. Submittal data and shop drawings shall be prepared and submitted in the following formats:

1. All drawings prepared for the project shall be developed using the AutoCADD program, most current version (or a CADD package capable of producing AutoCADD "DXF"-compatible format files).

2. All submittals data shall be the same size for any group of information and shall be in a three screw and post binder. (NO EXCEPTIONS). All the information shall be indexed and tabbed with reference to the specific section of these specifications.

3. The format for different groups of submittal information are as follows:
   a. Control drawings, building plans (including complete floor plans), schematics and system configurations shall be CADD prepared drawing, bound and indexed. Drawings that cannot represent the total information on an individual ANSI size B (11" x 17") drawing, i.e. a building plan, shall be noted with appropriate match lines, cross references and key plans.
   b. Technical data, sequence of operations, material list, point lists, program listings, I/O schedules, operator's and programmer's manuals, etc. shall be type written, original product data sheets or CADD prepared drawings, ANSI size A or ANSI size B.

4. Upon completion of the project and acceptance of systems the contractor shall provide to the Owner one set of hard copy as-built shop drawings and diskettes.

E. Shop drawings shall include riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.

F. When the Architect/Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.

G. Contractor agrees that shop drawing submittals processed by the Architect/Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Architect/Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use. The Contractor shall be responsible for space requirements, configuration, performance, changes in bases, supports, structural members and openings in structure, and other apparatus that may be affected by their use.

H. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.

### 1.5 DELIVERY, STORAGE AND HANDLING:

A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent any equipment damage, and to eliminate all dirt and moisture from equipment. Store all equipment and materials inside and protected from weather.

## PART 2 - PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS AND CONTRACTORS:

A. Subject to compliance with requirements, the system to be installed shall be Johnson Controls – Metasys Open Architecture.

B. Installers for field level controls and programming shall be JCI-authorized contractors pre-approved by the **LPS Operations, Maintenance and Construction (OMC) Department**.

C. Temperature Control proposals for work on the existing Johnson Controls ADX Platform server located at 5776 South Crocker Street, Littleton, CO 80120, are to be submitted directly to the Owner by Johnson Controls Inc., Milwaukee, WI. Once approved, the pricing and proposal will be delivered to bidding contractors through the Architect/Engineer for inclusion in the contractors bid proposal. Contractor must identify the JCI assigned subcontractor on the bid form.

### 2.2 GENERAL PRODUCTS DESCRIPTION:

A. The Building Automation System (BAS) shall be capable of integrating multiple building function including equipment supervision and control, alarm management, energy management, and historical data collection and archiving. All products and materials installed shall be suitable for the intended application requirements including but not limited to:

1. Accuracy
2. Rangeability
3. Temperature and pressure ranges
4. Shut-off pressures
5. Differential pressures

6. Repeatability
7. Materials of construction suitable with the environment and/or media in which they are in contact
8. Code compliance
9. Velocities

B. The BAS shall consist of the following:

1. Standalone DDC panels
2. Standalone application specific controllers (ASCs)
3. Portable Operator's Terminals
4. Personal Computer Operator Workstations
5. High Speed Communication Network (LAN)

The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC panel or combination of panels on the network without dependence upon a central processing device. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

E. Field level controls (those controls affecting new equipment and devices for the Project) are to be BACnet MSTP compatible and interface via the existing JCI ADX Platform.

F. Shared points will not be allowed.

G. BAS shall allow third party software to operate on personal computer workstation without any degradation to the controls operating normally.

## 2.3 NETWORKING/COMMUNICATIONS:

The design of the BAS shall network operator workstations and Standalone DDC panels as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via the local area network, or auto-dial telephone line modem connections, or via a combination on the two networking schemes.

A. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: All operator devices, either network resident or otherwise, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

a. Access to system data shall not be restricted by the hardware configuration of the BAS. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

3. General Network Design: Network design shall include the following provisions:
   a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum baud rate shall be 1 Mega-baud.
   b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.
   c. Detection and accommodation of single or multiple failures of either workstations, DDC panels, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
   d. Message and alarm buffering to prevent information from being lost.
   e. Error detection, correction, and retransmission to guarantee data integrity.
   f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
   g. Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.
   h. Use of industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst-case network loading.
   i. Synchronization of the real-time clocks in all DDC panels shall be provided.

## 2.4 STANDALONE DDC PANELS:

A. General: Standalone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control Processes
2. Energy Management Applications
3. Alarm Management
4. Historical/Trend Data for all points
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O
8. Manual Override Monitoring

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Digital Outputs for on/off equipment control
3. Analog Inputs for temperature, pressure, humidity, flow and position measurements
4. Analog Outputs for valve and damper position control, and capacity control of primary equipment

5. Pulse inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors and actuators.

The system architecture shall support a minimum capacity of [ %] for all types of DDC panels, and all point types included in the initial installation.

E. Serial Communication Ports: Standalone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals. Standalone DC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with the latest IEEE Standard 587.

1. Provide ISLATROL active tracking filters or equal, which provides both high and low voltage transients, non-linear characteristics, capable of instantaneously responding to spikes or transients without degradation to the filter or its performance. Power protection device shall be UL listed and have a reliability in excess of 100,000 hours of mean time between failures.

2. Signal wiring shall not be installed in same conduit as high voltage wiring.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

Should DDC panel memory be lost for any reason, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port., or via telephone line dial-in.

2.5 SYSTEM SOFTWARE FEATURES:

A. General

1. All necessary software to form a complete operating system as described in this specification shall be provided.

2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms.

   a. Two Position Control
   b. Proportional Control
   c. Proportional plus Integral Control
   d. Proportional, Integral, plus Derivative Control
   e. Automatic Control Loop Tuning

2. Equipment Cycling Protection; Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

C. Energy Management Applications: DDC panels shall have the ability to perform any or all of the following energy management routines.

- Time of Day Scheduling
- Calendar Based Scheduling
- Holiday Scheduling
- Temporary Schedule Overrides
- Optimal Start
- Optimal Stop
- Night Setback Control
- Enthalpy Switchover (Economizer)
- Peak Demand Limiting
- Temperature Compensated Load Rolling
- Fan Speed/CFM Control
- Heating/Cooling Interlock
- Cold Deck Reset
- Hot Deck Reset
- Hot Water Reset
- Chilled Water Reset
- Condenser Water Reset
- Chiller Sequencing

All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Execution portion of this specification.

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:
   a. Any system-measured point data or status
   b. Any calculated data
   c. Any results from other processes
   d. User-Defined Constants
   e. Arithmetic functions (+, -, *, /, square root, exp, etc.)
   f. Boolean logic operators (and, or, exclusive or, etc.)
   g. On-delay/Off-delay/One-shot timers.

2. Process Triggers: Custom processes may be triggered based on any combination of the following:
   a. Time interval
   b. Time of day
   c. Date other processes
   d. Time programming
   e. Events (e.g., point alarms)

3. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network.

   In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a connection to a remote device such as a printer or pager.

5. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphical flowcharts and English language descriptors.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English-language description, and the time and date of occurrence.

2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system

shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.

   Each standalone DDC panel shall be capable of storing a library of a least 250 Alarm Messages. Each message may be assignable to any number of points in the panel.

5. Auto-Dial Alarm Management: In dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

F. Historical Data and Trend Analysis: A variety of Historical Data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.

1. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs.

   The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all points shall be store for the past 24 hours to allow the user to immediately analyze equipment performance and all problem related events for the past day. Point History files for binary input or output points and analog output points shall include a continuous record of the last ten status changes or commands for each point.

2. Control Loop Performance Trends: Standalone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one second increments for verification of control loop performance.

3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of one minute to two hours, in one-minute intervals, shall be provided. Each standalone DDC panel shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 500 data samples.

4. Data Storage and Archiving: Trend data shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party person computer applications.

G. Runtime Totalization: Standalone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

1. The Totalization routine shall have a sampling resolution of one minute or less.

2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

H. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate, and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons, etc.).

2. The Totalization routine shall have a sampling resolution of one minute or less.

3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

I. Event Totalization: Standalone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

## 2.6 APPLICATION OF SPECIFIC CONTROLLERS - HVAC APPLICATIONS:

A. Each Standalone DDC Controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a Standalone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Points shall not be shared between controllers.

C. Each ASC shall have sufficient memory to support its own operating system and data base including:

1. Control Processes
2. Energy Management Applications
3. Operator I/O (Portable Service Terminal)

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation, or any PC or portable operator's terminal connected to any DDC panel in the network.

E. Application Specific Controllers shall directly support the temporary use of a portable service terminal. The capabilities of the portable service terminal shall include, but not be limited to, the following:

1. Display temperatures
2. Display status
3. Display setpoints
4. Display control parameters

5. Override binary output control
6. Override analog setpoints
7. Modification of gain and offset constants

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller..

## 2.7 AHU CONTROLLERS:

A. AHU Controllers shall support, but not be limited to, the following configurations of systems to address current requirements as described in the Execution portion of this specification, and for future expansion.

1. Large Air Handling Units
   a. Mixed Air-Single Path
   b. Mixed Air-Dual Path
   c. 100% Single Path
   d. 100% Dual Path

B. AHU Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally standalone fashion.

C. AHU Controllers shall have a library of control routines and program logic to perform the sequence operation as specified in the Execution portion of this specification.

D. Occupancy-Based Standby/Comfort Mode Control: Each AHU Controller shall have a provision for occupancy sensing overrides. Based upon the contract status of either a manual wall switch or an occupancy sensing device, the AHU Controller shall automatically select either Standby or Comfort mode to minimize the heating and cooling requirements while satisfying comfort conditions.

E. Continuous Zone Temperature Histories: Each AHU Controller shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

F. Alarm Management: Each AHU Controller shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

## 2.8 OPERATOR INTERFACE:

A. Basic Interface Description:

1. Command Entry/Menu Selection Process: Operator Workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

   The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

2. Graphical and Text-Based Displays: At the option of the user, Operator Workstations shall provide consistent graphical or text-based displays of all system point and applications data described in this specification. Point identification, engineering units,

status indication, and application naming conventions shall be the same at all workstations.

3. Multiple, Concurrent Displays: The Operator Interface shall provide the ability to simultaneously view several different types of system displays in overlapping windows to speed building analysis. For example, the interface shall provide the ability to simultaneously display a graphic depicting an air handling unit, while displaying the trend graph of several associated space temperatures to allow the user to analyze the system performance. If the interface is unable to display several different types of displays at the same time, the BAS Contractor shall provide at least two operator stations.

4. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password.
   a. Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and downloaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.
   b. A minimum of five levels of access shall be supported:
      1) Level 1 = Data Access and Display
      2) Level 2 = Level 1 + Operator Overrides
      3) Level 3 = level 2 + Database Modification
      4) Level 4 = Level 3 + Database Generation
      5) Level 5 = Level 4 + Password Add/Modification
   c. A minimum of 50 passwords shall be supported at each DDC panel.
   d. Operators will be able to perform only those commands available for their respective passwords. menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.
   e. User-definable, automatic log-off timers from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

5. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
   a. Start-up or shutdown selected equipment
   b. Adjust setpoints
   c. Add/Modify/Delete time programming
   d. Enable/Disable process execution
   e. Lock/Unlock alarm reporting for each point
   f. Enable/Disable Totalization for each point
   g. Enable/Disable Trending for each point
   h. Override PID loop setpoints
   i. Enter temporary override schedules
   j. Define Holiday Schedules
   k. Change time/date
   l. Enter/Modify analog alarm limits
   m. Enter/Modify analog warning limits
   n. View limits
   o. Enable/Disable demand limiting for each meter
   p. Enable/Disable duty cycle for each load.

6. Logs and Summaries: Reports shall be generated automatically or manually, and directed to CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

a. A general listing of all points in the network
b. List of all points currently in alarm
c. List of all off-line points
d. List all points currently in override status
e. List of all disabled points
f. List all points currently locked out
g. List of all items defined in "Follow-Up" file
h. List all weekly Schedules
i. List all Holiday Programming
j. List of limits and deadbands

Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

B. Dynamic Color Graphic Displays: Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, and hot water boiler systems, shall be provided as specified in the Execution portion of this specification to optimize system performance analysis and speed alarm recognition.

1. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention.

3. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

4. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
   a. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (i.e. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (i.e. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
   b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawings program to allow the user to perform the following:
      1) Define symbols
      2) Position and size symbols
      3) Define background screens
      4) Define connecting lines and curves
      5) Locate, orient, and size descriptive text
      6) Define and display colors for all elements
      7) Establish correlation between symbols or text and associated system points or other displays.
   c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aid the operator in the analysis of the facility.

To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

C. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the Operator. System definition and modification procedures shall not interface with normal system operation and control.

1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
   a. Add/Delete/Modify Standalone DDC Panels
   b. Add/Delete/Modify Operator Workstations
   c. Add/Delete/Modify Application Specific Controllers
   d. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
   e. Add/Delete/Modify alarm reporting definition for each point.
   f. Add/Delete/Modify control loops
   g. Add/Delete/Modify energy management applications
   h. Add/Delete/Modify time and calendar-based programming
   i. Add/Delete/Modify Totalization for every point
   j. Add/Delete/Modify Historical Data Trending for every point
   k. Add/Delete/Modify custom control processes
   l. Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
   m. Add/Delete/Modify all operator passwords
   n. Add/Delete/Modify Alarm Messages

2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.

   Graphical programming shall allow the user to define the software configuration of DDC control logic for HVAC system control sequences, fan interlocks, pump interlocks, PID control loops, and other control relationships through the creation of graphical logic flow diagrams.
   a. Graphical Programming: Control sequences are created by using a mouse input device to draw interconnecting (comparisons and mathematical calculations), and outputs of a control sequence. As a minimum, graphic symbols shall be used to represent:
      1) Process Inputs, such as temperature, humidity, or pressure values, status, time, date, or any other measured or calculated system data.
      2) Mathematical Process Operators, such as addition, subtraction, multiplication, or greater than, equal to, less than, etc.
      3) Logical Process Operators such as AND, OR, Exclusive OR, NOT, etc.
      4) Time Delays
      5) Process Control Outputs such as start/stop control points, analog adjust points, etc.
      6) Process Calculation Outputs
      7) Text file Outputs and Advisories
   b. Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single DDC panel, but shall be able to allow the development of all other DDC panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
   c. Sequencing, Testing, and Simulation: A software tool shall be provided, which allows a user to simulate control sequence execution to test strategies before they are actually applied to mechanical systems. Users shall be able to enter

hypothetical input data, and verify desired control response and calculation results via graphical displays and hardcopy printouts.

3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

4. Database Save/Restore/Back-Up: Back-up copies of all standalone DDC panel databases shall be stored in at least one personal computer operator workstation.

5. Continuous supervision of the integrity of all DDC panel databases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the system shall automatically download a new copy of the respective database to restore proper operation. Database back-up/Download shall occur over the local area network without operator intervention. Users shall also have the ability to manually execute downloads of any or all portions of a DDC panel's database.

D. A portable laptop computer shall be provided to the Owner upon completion of the project. The laptop computer shall include all necessary hardware and software to allow remote access of the complete BAS on or off the site via a modem phone line communication connection.

The laptop computer shall be configured to monitor, access, and make adjustments to the system and operate the same as the computer workstation described above.

The laptop computer shall have the following minimum configuration:

1. NEC Versa
2. Intel P5-133 mHZ
3. 16mB RAM
4. 12.1" Active color display
5. Local Video Bus with accelerator
6. PCMCIA Slots (2) Type II / (1) Type III ports: Parallel, Serial, CRT, PS/2 Keyboard mouse
7. Lithium Ion battery
8. 1 GB hard drive
9. 3.5" 1.44 mB floppy disk drive
10. Battery charger
11. 1 spare battery
12. MS-DOS 6.2 or higher
13. MS Windows '95
14. Integral Track Mouse
15. Targus Universal Case
16. Built-in 28.8 K bps Fax/Modem
17. MS Office '97 Professional
18. 155 V plug-in adapter power supply

E. Standalone DDC panel Local or Portable Operator's Terminals: Each DDC panel shall be capable of supporting an operator's terminal for local command entry, instantaneous and historical data display, and program additions and modifications.

1. There shall be a provision for both permanently mounting the stand-alone DDC panel Operator Terminal, or using it as a portable handheld unit.

2. The DDC panel Operator Terminal shall simultaneously display a minimum of 6 points with full English identification to allow an operator to view single c\screen dynamic displays depicting entire mechanical systems.

3. The operator functions provided by the DDC panel Operator Terminal shall include, but not be limited to, the following:
   a. Start and stop Points
   b. Modify Setpoints
   c. Modify PID Loop Setpoints
   d. Override PID Control
   e. Change Time/Date
   f. Add/Modify Start/Stop Weekly Scheduling
   g. Add/Modify Setpoint Weekly Scheduling
   h. Enter Temporary Override Schedules
   i. Define Holiday Schedules
   j. View Analog Limits
   k. Enter/ Modify Analog Warning Limits
   l. Enter/ Modify Analog Alarm Limits
   m. Enter/ Modify Analog Differentials
   n. View Point History Files

4. The DDC panel Operator Terminal shall provide access to all real or calculated points in the controller to which it is connected, or any other controller in the network. This capability shall not be restricted to a subset of predefined "global points", but shall provide totally open exchange of data between the operator terminal and any DDC panel in the network.

5. Operator access at all DDC panel operator Terminals shall be identical to each other, as well as identical to the PC or Laptop Operator Workstations. Any password changes shall automatically be downloaded to all controllers on the network.

6. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names. Prompting shall be provided consistent with a user's password clearance and the types of points being displayed, to eliminate the possibility of operator error.

7. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry. To minimize the possibility of operator error, the DDC panel Operator Terminal shall change and limit touchpad functions based upon an operator's password clearance, the function being performed, and types of points being displayed. Screen displays shall clearly indicate only valid touchpad functions.

8. Context-Sensitive Help: On-line, interactive user's "Help" manuals and tutorials shall be provided. Based upon operator request, the "help" function shall provide general system operating instructions, and specific descriptions of commands available in the currently displayed menus.

9. Identification for all real or calculated points shall be consistent for all network devices. The same English language names used at PC workstations shall be used to access points at the DDC panel Operator's Terminal to eliminate cross-reference or look-up tables.

10. In addition to instantaneous summaries, the DDC panel Operator's Terminal shall allow a user to view a Point History file for system points. Point History files shall provide a record of value of analog points over the last 24 hours, at 30-minute intervals, or a record of the last ten status changes for binary type points.

2.9 MATERIALS AND EQUIPMENT:

A. General: The Contractor shall provide control products in the sizes and capacities indicated. The existing control system shall remain and be reused as is. Additional controllers, sensors, and devices which are required to make a complete control system shall be the responsibility of the controls contractor.

| Select type of damper for each project. |
|---|

B. Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, double piece, 22-gauge galvanized steel mechanically joined, zinc plated steel concealed linkage and blade pin, oil impregnated bearings, self-compensating stainless steel side seals and silicone blade seals. Leakage rates shall not exceed 10 cfm/ft$^2$ at 4" w.c. static pressure differential for
a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

OR

Dampers shall be constructed of a minimum of 13 gauge galvanized steel frame, 1/16" extruded aluminum air foil blades, zinc plated steel concealed in frame linkage, zinc plated
steel blade pin, oil impregnated bronze bearings, self-compensating stainless steel side seals, neoprene blade seals. Leakage rates shall not exceed 7 cfm/ft$^2$ at 4" w.c. static pressure differential for a 24" x 24" damper. Provide extended shaft for proper and adequate actuator connection and operation. Damper blades shall not exceed 6" in height.

C. Damper blade operation shall be as follows:

| **APPLICATION** | **OPERATION** |
|---|---|
| Modulating Air Volume Control | Opposed Blade |
| Mixing Plenum | Parallel Blade/Opposed Blade |
| Isolation/Shut-off Service | Parallel Blade |

D. Pneumatic Dampers Operators (for replacement of existing pneumatic operators, only):

1. All damper operators shall be of the synthetic elastomer diaphragm piston-type and shall be fully proportioning unless otherwise specified. Dampers operators shall have metal bodies. The operators shall have ample power to overcome friction of damper linkage and air pressure acting on the damper blades. The damper operator

mounting arrangement shall be outside the airstream wherever possible. The operators shall have external adjustable stops to limit the stroke. The operator linkage arrangement shall permit normally open or normally closed positions of the damper as required by the sequence of operation.

2. Damper operators on modulating dampers that are sequenced with other control devices shall have a pilot positioner of the full relay type with an interconnecting linkage to provide mechanical feedback so as to accurately position and control the damper.

3. Pneumatic Type Damper (for replacement of existing, only): Size each actuator to operate dampers with sufficient reserve power to provide smooth modulating action or 2-position action as specified.

E. Automatic Control Valves:

1. Control valves shall have equal percentage plugs.

2. Control Valve Construction:
   a. Small Valves 1/2" through 1": Valves shall be constructed with a cast brass body and screwed ends. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless steel stem shall be provided. Bonnet, cage, and the stem and plug assembly shall be removable for servicing. Body rating shall be 400 psi at 150 deg. F.
   b. Valves - 1/2" through 2": Valves shall be constructed with a cast brass body and screwed ends. For special duty, valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.
   c. Valves - 2-1/2" and above: Valves shall be constructed with a cast iron body and have flanged connections.

| Include the paragraph below where required. |
|---|

   d. For motorized plug, butterfly and ball valves, the operator shall be provided with the valve by the valve manufacturer. See Section 23 05 23.
   e. Steam control valves shall be suitable for superheat conditions where superheat may occur in operating system conditions.

3. Control Valve Operators/Actuators:
   a. All automatic control valves shall be fully proportioning with modulating plugs for equal percentage of linear flow characteristics and shall be provided with actuators of sufficient power for the duty intended. Valve body and actuator selection shall be sufficient to handle system pressure which will be encountered on the project.
   b. Where required by the sequence of operation, valves shall be capable of being sequenced with other valves or with existing pneumatically actuated devices. Where such sequencing is required the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift can cause an overlap, a pilot positioning operator shall be furnished.
   c. Actuator housings shall be cast aluminum, with synthetic rubber diaphragm, spring return type.

4. Temperature control contractor and manufacturer shall size control valves for proper control characteristics for each application.

5. Water control valves shall be sized for a pressure drop between 4 to 6 psig at full flow condition.

6. Steam control valves shall be sized as follows:
   a. For line pressures 15 psig and less: The pressure drop across the valve shall be 80% of the inlet gauge pressure at full flow condition.
   b. For line pressures greater than 15 psig: The pressure drop across the valve shall be equal to the critical pressure drop which is 45% of the absolute inlet pressure.

7. Select valves to fail in normally open or closed position as follows:

Edit the following very carefully.

   a. Steam Convertors:
      1) Research Labs & Animal Labs:
         a) 2/3 Capacity Valve: N.C
         b) 1/3 Capacity Valve: N.C.
      2) Hospitals, Patient Care, Schools: N.O.
   b. Terminal Heating Devices:
      1) Offices, Patient Care, Hospital, Public Areas and schools: N.O.
      2) Research labs, computer equipment rooms, telephone equipment rooms, animal holding rooms, etc: N.C.
   c. Chilled Water Service:
      1) Offices, Patient Care, Hospital, Schools: N.C.
      2) Research labs, computer equipment rooms, telephone equipment rooms, animal holding rooms, etc.: N.O.
   d. All humidifier Valves: N.C.
   e. All Pre-Heat (Outside Air) Coil: N.O.
   f. or as dictated by life safety, freeze protection, humidity, fire or temperature protection.

## 2.10 INPUTS:

A. All input accuracies required by this section shall be end-to-end (from sensing point to BAS display). End-to-end accuracy includes all errors due to the sensor, transmitter, wiring and BAS signal measurement and A/D conversion.

B. Thermistors or solid state sensors shall be provided for temperature sensing applications except where accuracies or ranges required cannot be met by these devices, RTD's shall be used. The sensors shall be powered by the BAS panel or Dedicated Controller. The solid state sensors shall be accurate to within ±0.5 °F. over the following ranges and meet the following requirements:

   1. Room Type Instruments: 50 °F to 100 °F. For room space applications: Sensor shall be surface recessed mounted in a plastic aluminum/stainless cover with an insulated baseplate & vandal-proof screws.

      Each thermostat have the following features:

      a. Exposed/Concealed setpoint adjustment dial with temperature graduation indication.
      b. Exposed graduated temperature indicating thermometer.
      c. All/Public area thermostats shall be provided with a plastic/stainless steel vented, lockable security cover.

   2. Duct & Plenum Applications: -30° F. to 240 °F. Supply, return, exhaust or mixed air averaging type, which shall have an extended element of sufficient length to cover the entire duct cross-section with a minimum of three passes. If a single averaging thermistor of sufficient length to meet the preceding is not available, then two or more sensors and AIs shall be used and averaged in software.

3. Water Temperature Applications: 30 °F to 230 °F.

C. Where RTD's are required, they shall be 1000 ohm platinum type and be supplied with a 4-20 mA DC transmitter. The sensor and transmitter shall be a single unit. They shall be accurate to within ±1.0 °F. over the range of 32 °F. to 600 °F.

D. Where thermocouples are required, they shall be type J and be supplied with a 4-20 mA DC transmitter. They shall be accurate to within ±2.0 °F over the range of 32° F to 1300 ° F.

E. Provide matched temperature sensors for applications which require both inlet and outlet temperatures of any device.

F. Thermo-wells shall be monel, brass or copper for use in copper water lines; and 300 series stainless steel for all other applications.

G. Outdoor Air Temperature & Humidity Transmitter:

1. Provide Vaisala HMD60Y0 relative humidity and temperature probe with membrane filters and UV stabilized solar radiation shield. Probe shall have a temperature measuring range of -40 °F. to +120 °F. with an accuracy of ±.54° F at 68 °F. and relative humidity measuring range of 0 to 100% RH with an accuracy of 2% 0 to 90% RH with a repeatability better than 1% RH per year. RH and temperature probe shall be capable of a continuous temperature operating range of -40 °F. to +120 °F. Provide necessary transmitter for output signals.

2. Provide 1 spare set of protective filters for each transmitter Viasala No. 17039.

H. Humidity Transmitter:

1. Duct humidity transmitters shall be Vaisala Model HMD60U. Transmitters shall measure relative humidity from 0-100% RH with repeatable accuracy of ±2% RH. Long range RH stability shall be better than 1% RH/year. Duct mounting enclosure shall be cast aluminum, NEMA 4. Instruments shall be temperature compensated over entire range of operation. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type, 18.5 mm. Provide 4-20 mA output signal to building automation control system.

2. Wall Mounted Humidity Transmitter: Wall mounted humidity transmitter shall be Vaisala Model HMW60U. Transmitter shall measure relative humidity from 0 to 100% RH, ±2% accuracy, wall mounted ABS plastic box, with a long range RH stability better than 1% RH/year and temperature compensated over the entire range. Sensor shall utilize the registered HUMICAP H-sensor. Sensor filter shall be membrane type 18.5 mm and a 4-20 mA output signal.
   a. Provide 1 spare set of filters for each transmitter Viasala No. 17039.

I. Humidity and temperature calibrator kit:

1. Provide Viasala HMK41 Kit for single point calibration of air temperature and humidity transmitters. Kit shall include:
   a. HMI41 Sensor.
   b. HMP46 Probe.
   c. N.I.S.T. Certificate.
   d. 1911622 Calibration Cable.
   e. Carrying Case.

EDIT NOTE: Verify with Owner the need for a calibration kit. Cost is approximately $1200.00

J. Pressure Sensors, Transmitters and Differential Switches:

1. Pump/Liquid (wet) differential pressure switches shall be as manufactured by BARKSDALE with neoprene diaphragm, stainless steel internal parts, NEMA 4 housing.

2. Air Differential Pressure Transmitters shall be Modus model T30 or T40 (as required) with an accuracy of ±1% of range (including nonlinearity and hysteresis), solid state circuitry, no moving parts, capacitance principle capable of sensing positive, negative and differential pressures. Transmitter shall have 4-20 mA output signal and be powered by the control system or dedicated controller and capable of withstanding momentary overpressure of 8 times the pressure range.

3. Differential air pressure switches for filter or proof of airflow status shall be Dwyer Series 1910, with automatic reset, SPDT.

4. Hi-static pressure safety switches shall be Dwyer series 1900 MR, with manual reset, snap switch, SPDT, with repetitive accuracy within 3%.

5. Water/Liquid/Steam/Refrigerant Pressure Transmitter: Kele & Associates Model SA, stainless pressure transmitter with 4-20 mA output signal, watertight enclosure with stainless steel bulkhead fitting, accuracy of ±1% full scale, temperature compensated, 300 series stainless steel wetted parts.

   a. Provide Model 47S pressure snubber for applications where the transmitter is subjected to fluid hammer, pressure surge or pulsation.

   b. Provide Model PT steam syphon pigtail steam applications and where the fluid temperature is higher than maximum operating temperature rating of the transmitter.

6. Air and Vacuum Pressure Transmitter: Kele & Associates Model P100GTE, solid state, 4-20 mA signal, with a full scale accuracy of 1%.

K. Output Devices:

1. Control Relays: Control relay contacts shall be rated for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Provide with LED to indicate status.

2. Analog output transducers shall be of positioning type with position feedback and control internal to the transducer. As an option, position feedback may also be input to the BAS.

3. Analog output transducers shall meet the following requirements:
   a. 4-20 mA DC output.
   b. Two-pipe electromechanical design or microprocessor-based design.
   c. 3-15 psi output range adjustable to a 0-20 psi range minimum.
   d. Linearity, repeatability and hysteresis no greater than 2% of full scale.
   e. Air capacity of 1000 SCIM minimum.
   f. Air consumption of no more than 100 SCIM.

g. Pressure gauges shall be installed on the branch and supply lines.
h. Acceptable transducers are the Bellofram T1000, Fairchild T5700, Johnson N6810, Mamac EP-310 or an equivalent.

4. Electronic analog output transducers shall output a signal to match the controlled device. The Contractor shall be responsible for verifying the required signals for all controlled devices. Transducers shall be completely solid-state with no mechanical parts.

5. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed is a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Relays shall be equipped with coil transient suppression, devices to limit transients to 150% of rated coil voltage. Delayed contact openings or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of ±2% of setting.

6. Latching Relays: Latching Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

## 2.11 GAUGES:

A. General: Provide air pressure gauges for indication of supply and control air pressure at each branch for all control valve sizes 1" and larger, as well as all control dampers, all controllers, relays and EP and PE switches.

B. Air pressure gauges shall be a minimum of 1-1/2" diameter, resistant to effects of shock, pulsation and vibration, with a full scale accuracy of ±2.5%.

C. Round receiver gauges for continuous indication of analog values shall be 4" dial face instruments. Gauges shall be calibrated in appropriate units for the variable being measured and shall operate through their full range on a change in air pressure from 3 to 15 psi. Accuracy shall be plus or minus 1/2% of full scale.

## 2.12 POSITIONERS:

A. Positive positioning relays shall be provided on valve actuators and damper operators when required to provide sufficient power, sequencing and repeatability.

B. Provide for smooth gradual operation over operating span adjustment of 0 to 15 psi and start point adjustment of 3 to 10 psi.

## 2.13 CUMULATORS, SWITCHES AND MISCELLANEOUS ITEMS:

A. Provide all cumulators, switches and other miscellaneous items as may be required for successful operation of the temperature regulation systems specified herein and/or shown on Drawings.

B. Cumulators shall be of the positive and gradual acting type.

C. Provide suitable indicating plates with all switches.

D. Pressure/Electric switches shall be micro switch type.

E. Range shall be 0 - 20 psi with electrical rating of 10 amperes minimum for 115V/1/60.

2.14 POWER MONITORING:

A. General: Provide current switches, current transducers, voltage transducers, current transformers as required to meet the specified sequence of operation and indicated below.

B. Current Operated Switches: AC current switch, Neilsen-Kuljian Model PD50AC, or PD75, solid state, 5 year warranty, three selectable ranges for optimum adjustability and resolution. Provide external current transformer where required.

C. Current Transducers: AC current to DC current output, ±.5% accuracy, 4-20 mA output signal, Kele and Associates Model 4CMA. Provide external current transformer where required.

D. Voltage Transducers: Kele & Associates Model PVM or LVM as required for each application, ±1/2% accuracy, 4-20 mA DC output.

2.15 VIBRATION MONITORING:

A. Vibration Switch: Kele & Associates Model 502 vibration switch, frequency range of 120 to 30,000 CPM, 3 second time delay to prevent triggering due to transients 4-20 mA output signal, capable of being wired for automatic reset or latch and remote reset, ±5% accuracy, alarm setpoint and shutdown limit, NEMA 4 enclosure, capable of being mounted with the sensitive axis in any plane including inverted position and a velocity range of .15 to 1.5 in/sec.

EDIT NOTE: If duct mount is used, may need to filter air upstream of sensor. Verify with application, contact manufacturer's representative.

2.16 GAS DETECTION SENSORS:

A. Carbon Dioxide Sensor: SELECT WALL OR DUCT MOUNT. Viasala GMD20 (Duct) GMW20 (Wall); designed to monitor $CO_2$ levels, in accordance with ASHRAE Standard 62-1989, 4-20 mA output, accuracy at 20< C <(20ppm +1.5% of reading), 0-2000 PPM range, adjustable to 20000 ppm.

B. Refrigerant Leak Detection: MSA Instruments. "CHILLGARD RT" leak detection system, monitor and multipoint sequences, complies with ASHRAE Standard 15-1992, 0-100 PPM, 10% reading, 0-100 PPM linear reading, ±2% of full scale for 100-1000 PPM, 1 PPM sensitivity for R-123, resolution of 1 PPM, capable of 6 sampling points, suitable for either R-123, R-134A, R-22, ammonia, complete with alarm relays, 4-20 mA analog output, NEMA 4 enclosure, calibration kit, audible horns, zero & span gas scrubber.

C. Carbon Monoxide Sensor: Kele & Associates Model WCO-1, solid state sensor with a life expectancy of over 10 years, 0-200 PPM digital display, 4-20 mA analog output, test switch, automatic calibration and kit, alarm relay contact. Provide multiple sensors for adequate coverage. Each sensor shall be individually wired directly back to controller.

D. Oxygen Monitor Sensor: Davis Instruments Teledyne Model 335, with a range of 0-25% $O_2$, 0.5% sensitivity of full scale, ±2% accuracy at constant temperature, solid state electronics, two adjustable alarm setpoints and form C relay contacts, built-in audible and visual indication, AC-powered NiCad battery back-up and battery test switch. Provide calibration equipment and span gas.

2.17 TEMPERATURE CONTROL CABINETS:

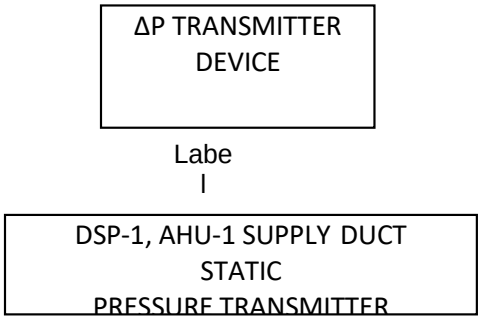
A. General: All controllers and field interface devices shall be installed in control panel cabinet/enclosure as described below.

B. Cabinets shall be UL listed, 14 gauge furniture grade steel, finished with baked enamel painted finish inside and out, cabinet doors shall have piano hinge and standard key cylinder locking latch.

Cabinets shall include Lexan windows to view controls without opening the door.

C. Control panels located outdoors shall be NEMA 4X.

D. All devices installed in or on the control cabinet shall be labeled with a fixed mounted, color contrasted, engraved laminated plastic tags, including describing the function of the device, similar to the following example:




E. New panels shall not include pneumatic devices except in special situations as pre-approved by the **OMC** **Department**. In such cases, pneumatic devices within the panel shall be factory pre-piped. A "pneumatic terminal" numbering system shall be applied to pneumatic lines within a panel with aforementioned numbers matching pneumatic terminals shown on control diagrams. This feature is required to assist system checkout and service.

F. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.

G. Mount control panels adjacent to associated equipment on vibration free walls or free standing steel angle supports or "Unistrut" support stand.

## 2.18 VARIABLE FREQUENCY DRIVES:

A. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

B. Automatic operation shall be from a 4-20 milliamp signal follower, which shall follow a transducer signal. The signal follower shall contain the following design features.

1. Shall accept a transducer output signal and condition it to produce a speed reference signal for the invertor.

2. Minimum speed adjustment (Zero to Maximum RPM).

C. Wire all safeties to operate both in hand and auto positions as well as drive and by-pass sections.

D. Provide communication cabling and interface necessary to forward VFD computer communication information to and from the BAS/VFD. See Section 23 05 13.

## 2.19 HIGH & LOW TEMPERATURE LIMIT CONTROL DEVICES:

A. Provide PENN A70 series or equal, DPST, manual reset, two isolated sets of contacts. Control responds to temperature along any one foot of entire element.

B. Vapor charged sensing element shall be calibrated for altitude of project site.

C. Provide multiple limit control devices as required to provide complete and full coverage of the entire coil face area and/or duct cross section area.

## 2.20 ELECTRICAL MATERIALS:

A. All wiring shall be installed in conduit. See Division 26 for conduit installation requirements. Where wiring is exposed in plenum locations (i.e. open cable tray), wiring shall be plenum-rated.

B. Conduit and Conductors: Types as indicated in Division 26 and sized per Division 26 except for low-voltage twisted pair or single jacketed cable (1/2" minimum). All low voltage conductors shall be stranded 22 gauge copper minimum; twisted pair.

C. Fittings per Division 26: Bushings or nylon insulated throats are not required for jacketed cables.

D. All J-boxes shall be identified and labeled per Division 26.

E. All conductors and cables shall be labeled per Division 26.

F. Conduit and box supports shall be per Division 26.

G. Junction boxes shall be of types and sizes as indicated in Division 26.

H. Conduits shall not exceed 40% maximum fill for single conductor and jacketed cables.

I. Fiber Optic Cable:

1. Acceptable fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140. Only glass fiber is acceptable, no plastic.

2. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

J. Coaxial Cable:

1. Coaxial cable shall conform to RG62 or RG59 rating.

2. Provide plenum rated coaxial cable when running in return air plenums.

K. All temperature control panels & controllers shall be provided with fuse protection on both incoming power load supply (primary side) and on low voltage side of control transformer (secondary side).

L. Provide lightning arresters Kele & Associates Model 392-SVSR2 or equal, at all points where communication cables exit or enter the building.

M. All communication cabling shall be shielded type.

## 2.21 CONTROL AIR PIPING MATERIALS:

A. General: Paragraphs below only describe the material types, see Part 3 - Installation for application, use and additional requirements.

B. Copper air tubing shall be hard drawn/soft type K or L, ASTM B88; wrought copper/cast-bronze fittings, joined with Evergleam 496 silver solder or equal 5% minimum silver content brazing alloy; except brass compression-type fittings at connections to equipment.

C. All polyethylene tubing shall be classified as flame retardant and shall be self-extinguishing and rated for plenum application (Type FR). The finished tubing shall be manufactured from a compound complying with subject UL94 Vertical Burning Test for classifying materials 94V-0, 94V-1 or 94V-2.

## 2.22 TEMPERATURE CONTROL AIR COMPRESSOR AND ACCESSORIES:

Use this Specification for up to 15 HP compressors to replace existing pneumatic systems, only, with pre-approval of the LPS Operations, Maintenance and Construction (OMC) Department. For larger systems, use Section 23 09 43 and make the appropriate coordination description.

A. Provide duplex type air compressor with sufficient capacity to supply compressed air to the temperature control system and sized to operate not more than 33% of time during any one-hour period.

Include compressor HP, SCFM & PSIG if you are selecting capacity, otherwise do not include.

B. Air compressor system shall consist of the following:

1. Duplex air compressor tank mounted factory pre-piped & wired with the following:
   a. Compressor and tank package shall be Quincy QR-25 system or approved equal, with a capacity of _____SCFM at 100 PSIG, _____RPM, _____HP/ea.
   b. Low resistance intake air combination filter/silencer, 99% filtration efficiency at 1 micron, sized for compressors rated flow.
   c. ASME stamped, galvanized steel tank receiver with a _____gallon capacity
   d. ASME safety relief valve.
   e. Discharge pressure gauge.
   f. One automatic condensate drain valve and one manual condensate drain mounted on receiver.
   g. Discharge check valves.
   h. Receiver shut-off valve.
   i. V-belt drive with adjustable motor drive bases.
   j. OSHA belt guards.
   k. Duplex motor starters and lead-lag alternator panel with individual fused disconnects, H-O-A switches, pilot lights, control transformer, with auto re-start on loss power. Starters and motors shall comply with Section 15040. Pump compressors shall run on high demand.
   l. NEMA rated pressure switches.
   m. Crankcase lubrication level indication.
   n. Air-cooled aftercooler.
   o. Low oil level shutdown safety switch.
   p. Pressure lubrication with positive displacement oil pump and spin-on oil filter.
   q. 5 year warranty.

C. Provide the following compressed air system accessories:

1. Air cooled Non-CFC EPA approved refrigerant, refrigerated air dryer sized to reduce dew point of control air supply to 35 º F., at 100 PSIG and 100< F. ambient temperature for the rated capacity of compressor system at SCFM. Air dryer shall include non-cycling hermetically sealed compressor with non-fouling, self-cleaning, smooth surface copper heat exchanger, self-regulating hot gas by-pass, self-contained integral automatic condensate drain, electric motor overload protection, refrigerant service valve, self-contained controls and the following instrumentation:
   a. Power ON light
   b. ON/OFF switch
   c. Low ambient control
   d. Refrigerant suction pressure gauge
   e. High temperature light

   Refrigerated air dryer shall be as manufactured by Wilkerson or Hankison, Model _____.
2. Provide primary efficiency coalescer filter between the compressor and refrigeration air dryer capable of particle removal down to .5 micron, with a maximum downstream remaining oil content of .5 ppm by weight at 99.97% efficiency, DOP test. Primary efficiency coalescer filter, Wilkerson filter type B or equal, sized for minimal pressure
3. Drop at rated compressor system flow. The primary efficiency coalescer filter shall be pre-filtered by a general purpose filter Wilkerson filter type A or equal, capable of removing particles sizes down to 5 micron.

   Each filter shall include a direct mounted differential pressure gauge indicating when a filter change is required by a change in color indicator as manufactured by Wilkerson Model DP1 or equal.
4. Provide extremely high efficiency coalescer filter on discharge side of refrigerated air dryer capable of particle removal down to .01 micron, with a maximum downstream remaining oil content of .01 ppm by weight at 99.9999% efficiency, DOP test.

   High efficiency coalescer filter shall be Wilkerson type C or equal, sized for minimal pressure drop at rated compressor system flow. Provide direct mounted differential pressure gauge as specified above for primary and primary coalescer filters.
5. Final filtration shall be an activated carbon element for removal of oil vapor whether petroleum or synthetic based to a remaining oil content of.003 ppm by weight based on Sodium Flame Test.
6. All filter housings shall be impact resistant high strength plastic bowls with quick disconnect metal bowl guard and safety latch OR all metal bowl with liquid level sight gauge and manual/automatic mechanical float with manual override drain valves. All filter housing seals shall be compatible with compressor lubricant.
7. Automatic Drain Devices:

| Edit the following types as required. |
|---|

   a. Fully automatic, float operated, non-electrical, Hankison Snap-Trap with pilot valve, magnet, float, orifice filter, stainless drain filter, separate manual override drain valve, metal bowl with sightglass, Viton Seals with a capacity of .3 gallon per hour based on cycle per minute.

| For large high moisture systems use the following paragraph. |
|---|

b. Fully automatic, heavy duty float operated, non-electrical Hankison Trip-L-Trap automatic drain, constructed of stainless steel, 300 psig maximum operating pressure, Viton seals, float and arm, pilot valve, magnet, with manual drain valve with a nominal capacity of 3 gallons per hour based on one cycle per minute.
c. Completely automatic electric timed drain valve(s), Hankison 532 Series, complete with solid state timer, ASCO diaphragm type solenoid valve with 1/2" orifice, external adjustment knobs, manual override switch, status light indication, 150/300 psig construction, rugged non-corrosive NEMA 4 construction, heavy duty class F coil. Timer shall be adjustable for drain time from .5 to 25 seconds and a time cycle between drain opening from 1 to 45 minutes.
d. Fully automatic electric demand drains Hankison 541/542 series, solid state controller, with capacitance sheath type sensor, pilot operated, alarm circuit automatically activates controller to switch to timed cycle with auto re-set after fault correction, two sets of auxiliary contacts for remote monitoring (1 N.O., 1 N.C.). NEMA 4 construction, status lights, manual override (push-to-test) buttonand multiple inlet port configuration to allow variety of piping arrangement and manual drain port. Capacity shall be selected for system operating conditions.

   Provide reservoir which is compatible with the system containments to be removed and electric internal heater with thermostat where installation may be subjected to temperatures below 35°F. ambient.

8. System Compressed Air Pressure Reducing/Regulators:
   a. Provide Fisher Model 67AFR, constructed of aluminum body, tamper resistant, with glass filter, outlet pressure gauge, internal relief and Kunkle Model 30 relief valve set for appropriate pressure relief protection to the system downstream of the regulator valve. Valves shall be sized and selected for proper pressure regulation and control by the manufacturer.

9. Point of use PRV: Where noted on drawings as point of use air piping PRV, provide Wilkerson modular air regulators R16/R26 or equal, with pressure gauge and mounting bracket.

10. Desiccant Dryer(s): Provide Wilkerson DE Series compact heatless air dryer Model capable of a dew point of -40°F., at_____SCFM flow rate, at_____psig inlet pressure and_____ inlet temperature with a maximum purge rate of_____SCFM (@ 70°F.), including the following features:
    a. Moisture indicator
    b. N.C. heavy duty solenoid valves
    c. Solid state timer
    d. Spring loaded desiccant beds and quick change screw-on towers
    e. High humidity alarm, with remote alarm, contact, electronic humidity sensor and outlet air shut-off valve
    f. Instrumentation package, including two tower pressure gauges and on/off switch
    g. Fungus proof construction
    h. Mufflers
    i. Manifold bracket, cover and screws
    j. After filter type AF .5 micron filter for removal of desiccant dust, complete with pressure regulator and gauge Wilkerson Series RIG/R26 and safety relief valve.
    k. Explosion-proof construction.

2.23 END SWITCHES:

A. All end switches shall be NEMA rated contacts and NEMA 4X enclosure, either SPDT, DPDT DPST as required to meet the sequence of operation, complete the points list and necessary interlocks or safeties control wiring. End switches shall be as manufactured by Cutler- Hammer or Allen-Bradley.

B. All end switches shall be designed and configured to provide positive indication of a control device (i.e., damper or valve) position for the service intended.

PART 3- EXECUTION

3.1 INSTALLATION:

A. The Contractor shall install all equipment, control air piping/tubing, conduit and wiring parallel to building lines.

B. All automatic control valves and control dampers furnished by the Temperature Control Contractor shall be installed under his supervision by the Mechanical Contractor.

C. GENERAL INSTALLATION REQUIREMENTS:

1. Spare conductor capacity, equal to a minimum of (2) additional sensors shall be provided to each underfloor sensor and pendant type sensors.

2. Wiring shall be installed in conduit throughout.

3. Horizontal runs of conduit, trays, tubing or wiring shall be hung from structural members using new supports, or where feasible, utilizing existing temperature control conduit and piping. The Contractor shall verify adequacy of existing systems and warrant these systems as if they were new. Single runs of conduit, tubing or wire shall be by clevis ring and all thread rod. Multiple runs shall be by "Trapeze" or "Unistrut" supports. "Plumber's Strap" shall not be allowed. Maximum distance between supports shall be per the NEC. Existing supports shall only be used upon written concurrence by the Architect, Engineer or Owner.

4. All vertical runs of conduit or tubing shall be through new core drills. Existing core drills may be used if approved by the Owner. The installation shall be supported above each floor penetration using clamps to "Unistrut".

5. All wire that enters or leaves a building structure shall be installed with lightning protection per NEC.

6. All wire terminations shall be with compression type round hole spade lugs under a pan head screw landing; Stay-Kon or equivalent. All wire splices shall be with compression type insulated splice connectors or properly sized "wire-nut" connectors. Hand twisted, soldered and/or taped terminations or splices are not acceptable.

7. Where tubing, wiring or conduit penetrate floors or walls, sleeves with bushings shall be provided for tubing and wires. The conduit or sleeve opening shall be sealed with fire proof packing so the smoke and fire rating of the wall or floor is maintained.

Edit the following paragraph for each project.

8. Under no circumstances shall wire, tubing, tray, J-boxes or any BAS equipment be run in, mounted on, or suspended from any of the telephone system's equipment, cable trays or support structure (Grey Iron).

9. All the material installed under this contract must be mounted on, or supported from the building structure or supports furnished by this Contractor.

Edit the following paragraph for each project.

10. All air for new pneumatic BAS devices (replacing existing pneumatic devices only, as pre-approved by the LPS OMC Department) shall be obtained from the existing pneumatic system.

11. Air supplies shall be supplied from mains. Do not connect to branch lines.

12. Provide an isolation valve on air line connections to each air controlled device which will be added.

13. Install 0-20 psi pressure gauges at all air controlled devices which will be added.

D. CONTROL AIR PIPING AND TUBING:

1. Provide and install control air piping and tubing as specified in the following table:

Edit the following table for each project.

| **APPLICATION/LOCATION** | **MATERIAL/INSTALLATION** |
|---|---|
| ALL PIPING | COPPER IN CONDUIT |
| ALL PIPING | COPPER WITHOUT CONDUIT/OR PLASTIC IN CONDUIT |
| SURFACE MOUNTED IN SERVICE/UTILITY AREAS. (I.E. LOADING DOCKS, GARAGE) | COPPER/OR PLASTIC IN/CONDUIT |
| MECHANICAL ROOMS | COPPER IN WITHOUT CONDUIT OR PLASTIC IN CONDUIT |
| ABOVE LAY-IN CEILINGS | COPPER OR FLAME RETARDANT POLYETHYLENE 25/50 FLAME/SMOKE RATING PLENUM RATED PLASTIC/ WITHOUT/IN/CONDUIT |
| SHEET ROCK, PLASTER OR OTHER SIMILAR NON-ACCESSIBLE CEILING SYSTEMS | COPPER IN/WITHOUT/CONDUIT |
| SHAFTS, CHASES, DROPS IN WALLS | COPPER/OR/FLAME RETARDANT POLYETHYLENE 25/50 FLAME/SMOKE RATING PLENUM RATED PLASTIC/WITHOUT/IN/CONDUIT |
| OTHER APPLICATIONS NOT GIVEN ABOVE | COPPER/IN CONDUIT |
| LIFE SAFETY SYSTEMS (I.E. SMOKE DAMPERS) | COPPER (BRAZED), MINIMUM 5% SILVER CONTENT |

2. Piping shall be installed horizontally level or vertically plumb with adequate pitch to drip pockets. No piping shall be concealed within duct insulation. All piping shall be supported using straps, cleats or hangers; wire will not be permitted. Where more than one (1) pipe in enclosed in conduit or tray, furnish color coded or numbered piping. Type FR polyethylene tubing may be used in local control panels that are enclosed or have side panels.

3. All accessory pneumatic and pneumatic-electric devices allowed by the **LPS OMC Department** as prescribed herein shall have a pneumatic test point on the device output which will allow the output signal to be measured without interruption of the control function.

E. Control Wiring:

1. Run wiring in metallic conduit, tubing or raceways. Exceptions are as follows:
   a. NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable (when approved by code authority).
   b. Wiring enclosed in temperature control panels.

2. Where conduit is used, provide steel fittings.

3. Low Voltage Conductors: 18 gauge minimum, except 19 gauge may be used for home runs to central panels and 22 gauge minimum for resistance or thermistor sensing element connections.

4. Wire control interlocks and control panels, except one 120V power circuit to each temperature control panel shown on drawings and schedules to be provided under Division 26.

5. All wiring shall comply with the requirements of local and national electrical codes.

6. Do not interlock alarms with starter switching to bypass alarm when equipment is manually disconnected.

7. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.

8. All costs of controls, wiring conduit and associated labor shall be included in the temperature control bid. The control wiring shall be installed under the supervision of this Contractor.

3.2 ENCLOSURES:

A. The tubing and wiring within all enclosures shall be run in plastic trays. Tubing and wiring within BAS panels may be run using adhesive-backed tie wraps.

B. All plastic tubing shall be connected to enclosures through conduit. All copper tubing shall be connected to enclosures through bulkhead fittings.

C. Mount all enclosures, including those which house BAS Panels, Slaves and Field Device Panels, so that the top of the enclosure does not exceed six feet, six inches (6'-6"); and the center of any keypad/LCD combination does not exceed five foot, six inches (5'-6") from the floor or is less than four feet zero inches (4'-0") from the floor.

D. Field Device Panels contain related Field Devices such as relays, control power (24V) transformers, output transducers, etc., that are outboard of the BAS Panels or Dedicated Controllers. Each Field Device Panel shall be mounted within an enclosure. The enclosures shall be provided with lockable latches that will accept a single key common to all Field Device Panels, BAS Panels and Slaves.

3.3 EXISTING CONTROLS:

A. Remove all existing controls, controllers, receiver/controllers, thermostats, sensors, field devices, gauges, etc.; and all associated wiring, piping and mounting hardware whose functions are being replaced by the BAS.

Edit MOP paragraph below for each project.

1. When existing equipment is removed, coordinate with a detailed Method of Procedure (MOP). Do not remove until Owner reviews.

2. Refer to General Conditions.

3.4 INSTALLATION PRACTICES:

A. The Contractor shall install and calibrate all Field Devices, sensors and transducers necessary for the complete operation of the I/O points described herein.

B. Sensors shall be removable without shutting down the system in which they are installed.

C. All immersion sensors shall be installed in new, welded thermo-wells supplied by the Contractor. Existing thermo-wells may be reused with concurrence from the Owner. Coordinate any required shutdown with Owner.

D. Thermistor wire leads shall be permanently terminated at panels or controllers with wire clamps.

E. Where none exist, furnish and install pressure/temperature gauges adjacent to each immersion type sensor.

F. Sensors shall be installed with the use of a wet or hot tap without draining the system if required.

3.5 CLEANING AND FLUSHING:

A. All control air tubing shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil, and any other material foreign to the air being circulated.

1. Clean exterior surfaces of installed piping systems of superfluous materials. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

2. After installation of piping, but prior to installation of outlet valves, blow lines clear with Grade "D" oil-free dry air or nitrogen.

3. Control air piping which is required to be brazed shall be provided with a nitrogen purge during the brazing process.

3.6 CONTROL AIR LEAK TESTING:

A. All new control air piping and tubing systems shall be tested at 30 psi with no loss of pressure over an 8 hour period. The test shall be witnessed by the Architect, Engineer or Owner.

B. Ensure that the test pressure which might damage equipment does not reach such units by valving them off or otherwise isolating them during the test.

C. Open and close all system valves at least once while the system is pressurized to test valve packing. Tighten as required.

3.7 IDENTIFICATION:

A. All control air piping/tubing, J-boxes, conduit and wiring shall be labeled.

B. Electrical devices, wiring, conduit and J-boxes shall be labeled and identified as required by Divisions 26, 27 and 28.

C. Main supply control air piping and tubing shall be labeled with Brady or equivalent markers or pre-printed identification sleeves at each end and junction point, and protected. Identification scheme shall be consistent with the drawings.

D. Identification shall be provided for all enclosures, panels, junction boxes, controllers or field devices. Laminated, bakelite nameplates shall be used. The nameplates shall be 1/16-inch thick and a minimum of 1 inch by 2 inches. The lettering shall be white on a blue [ ] background with minimum 1/4-inch high engraved letters. The nameplates shall be installed with pop rivets.

1. All new devices will be tagged. Color code to differentiate between new devices.

E. Thoroughly clean the surface to which the label shall be applied with a solvent before applying the identification. Use an epoxy to affix the identification in addition to any adhesive backing on the identification.

F. The plan code designation shown on all shop drawing identification shall be consistent with the contract documents.

G. All I/O Field Devices that are not mounted within Field Device Panel enclosures shall be identified with engraved plastic laminated nameplates installed so that they are visible from ground level.

H. The identification shall show the designation used on the record documents and identify the function such as "mixed air temperature sensor" and "fan status DP switch".

I. Calibration settings shall be marked with paint or indelible ink.

3.8 LOCATIONS:

A. All sensing devices and locations shall be located by the Contractor as shown on the submittal shop drawings with final review by the Engineer.

B. Wall mount space sensors shall be mounted five (5) feet above finished floor. Pendant mount space sensors shall be mounted eight (8) feet above finished floor.

C. Enclosures housing Field Devices shall be located immediately adjacent horizontally to the BAS panels or Slaves which are being interfaced to.

3.9 VALVES, WELLS, FLOW SWITCHES AND AUTOMATIC CONTROL DAMPERS:

A. The Controls Contractor shall have his control equipment on the project site when required and give the Owner 24 hours' written notice when systems must be shut down for installation.

3.10 TEMPERATURE SENSORS:

A. Temperature controls trades shall verify all wall mounted temperature sensors locations with the Architect/Engineer/Owner in order to avoid interference with wall mounted and space furnishings.

1. Where interferences require moving the temperature sensor more than two feet, consult with the Architect/Engineer for relocation.

B. Temperature sensors shall be mounted on suitable insulated base and secured to the wall in such a way as to be easily removed from wall without damage to the sensor.

C. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 60" (1524 mm) above finished floor.

## 3.11 EQUIPMENT PROTECTION AND COORDINATION:

A. Where existing walls are penetrated with conduit or piping, provide a fire stop assembly which meets or exceeds the original rating of the assembly. Refer to other sections of Divisions 20 through 25.

B. Extreme care must be exercised while working in existing facilities and around operating equipment, particularly sensitive telephone switching and computer equipment. Close coordination with the Owner is required for the protection of this operating equipment from dust, dirt and construction material while maintaining the operational environment for the equipment. Under no circumstances shall the power or environmental requirements of the operating equipment be interrupted during the installation and check-out without submitting to the Architect, Owner and Engineer for approval.

C. A detailed Method Of Procedure (MOP) stating the steps to be taken, time schedule and impacted systems for the service interruption shall be submitted to the Architect for approval prior to beginning work. Refer to LPS General Conditions of the Contract and other sections of Divisions 20 through 26 for requirements.

## 3.12 CLEANUP:

A. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned and all other areas shall be cleaned around equipment provided under this contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of all grease, plaster, dust, or other foreign materials.

B. Upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings. Use extreme care in cleaning around telephone switching and computer equipment and under no circumstances shall water or solvents be used around this equipment.

C. At the completion of the work and at the end of each work day, remove from the building, the premises, and surrounding streets, etc., all rubbish and debris resulting from the operations and leave all equipment spaces absolutely clean and ready for use.

## 3.13 SOFTWARE, DATABASE AND GRAPHICS:

A. Software Installation: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphics: Unless otherwise directed by the Owner, the Contractor will provide color graphic displays for all systems which are specified with a sequence of operation, depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

## 3.14 TEMPERATURE CONTROL DRAWINGS:

A. Upon completion of project and after record drawings of the temperature controls have been prepared and reviewed, the Contractor shall provide one (1) complete set of temperature controls drawings at each temperature control panel. Each set of drawings shall be laminated in a plastic coating. The drawings shall consist of only those control functions associated with the specific control panel and any relevant or pertinent network interface information.

The laminated drawings shall have a grommet connection attached to a metal cable or chain which is mechanically fastened to the temperature control cabinet.

## 3.15 START UP AND TESTING:

A. Prior to Beneficial Use of the BAS, the Contractor shall supply to Architect/Engineer two (2) debugged printouts of all software entered into the BAS. Also supply all users' programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:

1. Point data base.
2. All custom control programs written in the BAS control language.
3. All parameters required for proper operation of BAS control and utility firmware such as start-stop routines, etc.
4. Printouts or plotted detailed copies of the complete interactive system graphics.

B. The software printout shall be fully documented for ease of interpretation by the Architect/Engineer and Owner, without assistance from the Contractor. English-language descriptions shall be either integrated with or attached to the BAS printout. Specifically, the following shall be documented:

1. All point (I/O and virtual) names.
2. All BAS Programming Language commands, functions, syntax, operators, and reserved variables.
3. Use of all BAS firmware.
4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable for use in this documentation requirement.
5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, etc.

C. Documentation that was supplied as part of the submittals need not be submitted at this time.

Edit the following paragraph based on the Engineer's scope of work contract with the Architect or Owner.

D. Upon review of software, a point-to-point test of the BAS installation shall commence. The Contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. This procedure shall occur during off hour periods. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the BAS shall be provided by and operated by the Contractor. The Engineer and/Owner will be present to oversee, observe, and review the test. Demonstrate compliance that system functions per the Sequence of Operation.

1. Upon review of the point-to-point demonstration, the Contractor shall start up the BAS by putting all controlled equipment in automatic and enabling software. Contractor shall commence final software and overall BAS hardware/software debugging.

***Edit for 2 & 3 applicable projects.***

2. The point-to-point demonstration shall include any existing BAS equipment if it affects the operation of the equipment included under this contract.

3. As a minimum, existing conditions shall be maintained during system changeover.

E. Final acceptance of the BAS is contingent upon a hardware/software system test. All groups of points that yield a system of control shall be tested for compliance with the sequences of operation. Included in the test, but not limited to, shall be:

1. BAS loop response. The Contractor shall supply a trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set point which represents a change in the actuator position of at least 25% of its full range. The sampling rate of the trend shall be from one to three minutes depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that does not yield temperature control of + 0.2< F or humidity control of + 3% RH shall require further tuning by the Contractor.
2. Interlocks and other sequences.
3. BAS control under HVAC equipment failure.
4. HVAC operation under BAS equipment failure.
5. Battery backup.
6. BAS control under power failure/restart.
7. Reset schedules.
8. BAS alarm reporting capability.

F. A detailed test report as defined under Submittals shall be provided indicating its completion and proper system operation.

G. The BAS will not be accepted as meeting the requirements of Beneficial Use until all tests described in this section have been performed to the satisfaction of both the Architect/Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor shall be exempt from the Beneficial Use requirements if requested in writing by the Contractor and concurred by the Owner and Architect/Engineer. Such tests shall be performed as part of the BAS warranty.

1. A typed written document stating that the system has been fully checked out on a point by point basis shall be submitted to the Architect/Engineer. All documentation associated with the checkout shall be included.

3.16 PROJECT RECORD DOCUMENTS:

A. The Contractor shall be responsible for updating all existing Project Record Documents associated with the Scope of Work outlined in the Drawings and Specifications.

B. Prior to final completion of the installation, prepare a complete set of record drawings on a clear and legible set of ANSI size 'B' (11" x 17") mylar reproducible prints. Content, format and procedure of the submittal shall be as described by the LPS General Conditions of the Contract.

C. Provide one laminated and framed set of control drawings for each new BAS control panel and one for the Facility Control Room, located as directed by the Engineer.

Edit the following as required.

D. Prior to final completion of the installation, prepare three (3) operation and maintenance manuals. The information is to be inserted in the existing operation and maintenance manuals or provided in a tabbed and indexed, 3-screw and post binder. The information shall include:

1. Operator's manual with step-by-step procedures for logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware parameters.

2. Programmer's manual with complete description of the custom control language and associated editor, including sample written programs. Provide complete sets of all programming forms, applications memorandums, and addenda to the programmer's manual. All software or firmware algorithms shall be completely described and documented.

3. Maintenance, Installation, and Engineering manual(s) that clearly explains how to debug hardware problems, how to repair or replace hardware, preventive maintenance guidelines and schedules, calibration procedures, and how to engineer and install new points, panels, and Operator Interfaces.

4. Documentation of all software. List separately all software parameters that will need updating by the Owner such as, though not limited to, holiday, seasonal and start/stop schedules, comfort and duty cycling schedules.

5. All programs, code, databases, graphic files, CADD drawings and symbol libraries generated for operation of the system shall be included as a part of the system documentation. This information shall be submitted both in hard-copy bound format and electronic media format.

6. Input/output schedules, data sheets, and all other items required under Submittals. Describe all regular maintenance that will need to be performed on the BAS hardware. List replacement parts with part numbers.

7. Complete original issue documentation and software diskettes for all third party software furnished and installed as a part of the system or required for the operation of the system including text editors, control language program and compiler,

database managers, graphics and CADD packages, operating systems and communications software.

8. Complete original issue documentation, installation and operational manuals and supporting software for all third party hardware furnished and installed as a part of the system or required for the operation of the system including remote terminals, user's computer workstation, monitors, graphics and memory boards, printers and modems.

9. During the warranty period, all copies of the drawings and manuals shall be updated to include all hardware and software changes. A final update at 1 year shall be provided to the Owner.

E. All of the above documentation shall record both the equipment installed under this contract and the exact termination to all other existing control or BAS equipment.

F. The record drawings shall document the complete existing control system. This includes all mechanical equipment in work area which has automatic control.

3.17 WARRANTY:

A. The Warranty period shall begin on the date of Final Completion and Acceptance as certified by the Architect/Engineer and Owner in writing. Beneficial use shall not occur before the Contractor has performed the tests required. With these requirements met, beneficial use shall not occur until, in the opinion of the Architect/Engineer, the BAS is sufficiently complete to be utilized for the purposes for which it is intended.

1. The warranty start date shall not begin until all phases of the Project are complete—i.e., the Project shall have a single warranty start date.

B. The BAS system shall be guaranteed to be free from defects in material and workmanship and in software design and operation for a period of the warranty after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure the proper operation of, and to provide all required current and preventive maintenance. This warranty shall become effective starting the date of certified Final Completion and Acceptance.

1. The hardware warranty shall include all equipment which has been purchased by the Contractor. The existing hardware is not subject to the warranty requirements.

2. All software work completed by the Contractor, associated with existing hardware, is subject to the warranty requirements outlined herein.

3. The Contractor shall respond to all calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist.

4. The response time to any problems shall be four (4) hours maximum 24 hours per day, 7 days per week. Corrective action, temporary or permanent shall be made within one business day.

C. The Contractor shall perform a monthly on-site or via telephone MODEM inspection of the operation of the system. They shall report to the Owner in writing after each inspection, define any problems with the system and its operation, and define the procedure which will be taken to correct the problem. Contractor shall comment on the possible resolution of any problems that are out of the scope of their Contract.

1. Any problems shall be corrected as required by the warranty requirements.

D. The system shall be polled via the telephone modem for any alarm signals or "abnormal off" messages. Upon receiving such a message the Contractor shall take indicated corrective action.

E. The Contractor shall maintain a backup of all BAS software installed in the system. The backup shall be updated monthly or whenever a change to the software is made. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.

F. The Contractor shall optimize all control software to assure acceptable operating and space conditions, and peak energy efficiency.

G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all Project Record Documentation. This includes final updated drawings, software documentation and magnetic media backups that include all changes that have been made to the system during the warranty period.

## 3.18 TRAINING:

***Adjust number of hours of training based on size and complexity of project.***

A. The Contractor shall provide [__] hours of training for the building operators. The training sessions shall be broken into [__] [__]-hour sessions. The training session shall be made available to the Owner prior to the end of the warranty period but after final completion of the contract. The session shall be given at the Owner's facility. Scheduling shall be approved by the Owner. The training shall focus on general design, operation, and maintenance procedures of the products installed, though not necessarily the specific system designed, and shall cover:

1. Hardware configuration including PC boards, switches, communication and point wiring, and location and installation of all sensors and control devices.

2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.

3. Operation of man-machine interface including logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware/software parameters.

4. Programming the BAS using the editor and the design of custom control software.

5. Recovery procedures from both BAS and HVAC failures.

B. The Instructor for the above session shall be an employee of the Contractor, who is qualified to provide customer training and applications support.

## 3.19 SEQUENCE OF OPERATION:

See requirements of Section 23 09 93.

**END OF SECTION 23 09 23**

# SECTION 23 09 93 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.

B. Operating equipment, devices, and system components required for control systems are specified in other Divisions 20 through 25 Controls' sections of these specifications.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS:

A. Provide control systems consisting of thermostats, control valves, dampers, operators, indicating devices, interface equipment, and other apparatus required to operate mechanical system and to perform functions specified.

B. Provide necessary materials and field work necessary to connect control components factory supplied as part of equipment controlled, unless specified otherwise. Generally, self- contained valves, filter gauges, liquid level controllers and similar instruments, are not to be installed under this section.

C. Unless specified otherwise, provide fully proportional components.

D. Provide all necessary relays and signal boosters to make the system a full and operable system as required by the sequence of operation.

PART 3 - EXECUTION

| Edit each item for job needs. |
|---|

| NOTE: Provide normally open control valves for heating system with the exception of animal facilities or special areas, which require a normally closed valve. |
|---|

3.1 TERMINAL UNITS' CONTROL SEQUENCES:

A. Hot Water/Steam Heating Finned Tube/Baseboard/Radiation Convector: Provide wall mounted thermostat to automatically modulate a normally open/closed two-way control valve to maintain the thermostat setting. In rooms, which also have a terminal-heating coil, thermostat shall sequence the FTR valve with the heating coil valve to maintain stat set temperature.

B. Hot water/Steam Unit Heater: Provide wall/unit-mounted thermostat to automatically modulate a normally/open/closed/two way control valve/cycle the fan motor to maintain the thermostat setting.

C. Hot Water/Steam Cabinet Unit Heaters: Provide wall/unit-mounted thermostat to automatically modulate a normally/open/closed/two way control valve/cycle the fan motor to maintain the thermostat setting.

D. Hot Water/Steam/Chilled Water Fan Coil Units: Provide wall/unit mounted thermostat to automatically modulate the normally open two-way heating and normally closed cooling coils control valves and cycle the fan motor/and the fan shall run continuously to maintain the space thermostat heating and cooling settings.

E. Hot Water/Steam Unit Ventilators: Provide ASHRAE [Cycle I, 100% outside air at all times except during warm up state.] [Cycle II, a minimum amount of outdoor air (25%) (50%) is admitted during the heating and ventilating state and is increased to 100% as needed during the ventilation cooling stage.] [Cycle III, a variable amount of outdoor air is admitted, except during the warm-up state, as required to maintain a fixed temperature of air entering the heating coil. Air admission is controlled by an airstream thermostat set at 55°F (13°C) to provide cooling as needed.]

1. Cooling and Ventilating Stage: As space temperature rises above the thermostat setting, the normally open heating valve closes, the outdoor air damper modulates open from the air stream thermostat to maintain thermostat setting.

2. Warm-up Stage: The normally open heating control valve opens to 100% and the outdoor air damper is 100% closed until the space temperature setting is reached.

3. Heating and Ventilating Stage: As space temperature rises above the thermostat setting, the outdoor air is closed. On drop in temperature the reverse occurs.

F. Hot Water Heating Duct Coil: Provide wall-mounted thermostat to automatically modulate a normally open two-way valve to maintain the thermostat setting.

G. Gas Fired Propeller Unit Heater: Provide a line voltage unit/wall mounted thermostat to cycle the burner and fan motor on and off to maintain the thermostat setting.

H. Gas Fired Makeup Air Units: Provide a discharge air duct temperature sensor to cycle the burner on and off to maintain 55°F [+/-3°F] discharge air temperature.

I. Gas Fired Infrared Heaters: Provide a wall-mounted thermostat to cycle the infrared heater[s] burner on and off to maintain thermostat setting.

J. Electric Baseboard Radiation/Convectors: Provide a concealed/unit mounted/wall mounted thermostat to cycle the electric heating element on and off to maintain the thermostat setting.

K. Electric Cabinet/Unit Heaters: Provide a concealed/unit/wall-mounted thermostat to cycle the electric heating element and fan motor on and off to maintain thermostat setting.

L. Electric Wall Mounted/Toe Space Heaters: Provide concealed unit mounted thermostat to cycle the electric heating element and fan motor on and off to maintain thermostat setting.

M. Electric Radiant Ceiling Panel Heater: Provide a wall-mounted thermostat to cycle the electric radiant ceiling panel[s] on and off to maintain thermostat setting.

N. Electric Ceiling Heater/Exhaust Fan/Light: Provide all mounted separate on-off controllers for all functions and programmable timer switch/in line thermostat to control the heating cycle only.

## 3.2 TERMINAL BOX CONTROL SEQUENCES:

A. Constant Air Volume Without Reheat: The constant volume, pressure independent terminal box shall supply the scheduled air quantity independent of supply duct static pressure and temperature.

B. Constant Air Volume With Reheat: The constant volume, pressure independent terminal box shall supply the scheduled air quantity independent of supply duct static pressure. On a drop in temperature below set point, the thermostat shall modulate the reheat coil normally open/closed two-way control valve to meet set point.

C. Variable Air Volume Without Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop or rise in temperature below or above set point, the thermostat shall modulate the airflow between minimum and maximum scheduled air quantities to satisfy the thermostat set point.

D. Variable Air Volume with Reheat: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in room temperature below thermostat set point, the thermostat shall modulate the airflow minimum scheduled air quantity to satisfy thermostat cooling set point. On further drop in room temperature below thermostat heating set point, the thermostat shall modulate the reheat coil normally open/closed two-way control valve and increase the air flow to satisfy thermostat set point. On rise in temperature above the thermostat set point, the thermostat shall close the normally open/closed two-way control valve and modulate the airflow to maximum scheduled air quantity.

E. Variable Air Volume With Reheat Interlocked With Finned Tube Radiation: The thermostat shall control the damper operator on the variable volume, pressure independent terminal box. On a drop in temperature below cooling set point, the thermostat shall modulate the airflow to minimum scheduled air quantity to satisfy cooling set point. On further drop in temperature below heating set point, the thermostat shall modulate the VAV box reheat normally open/closed two-way heating control valve and the finned tube radiation normally open/closed control valve to satisfy heating set point.

## 3.3 AIR CURTAIN CONTROL SEQUENCES:

A. Air Curtain: The air curtain fan shall run continuously and the two-way normally open/closed control valve shall be controlled by a thermostat. On demand for heat, the normally open/closed two-way control valve shall modulate open to satisfy set point. Above set point, the normally open/closed two-way heating control valve shall be closed.

## 3.4 HEAT TRANSFER CONTROL SEQUENCES:

A. Preheat Glycol:

1. The heat exchanger/pump assembly shall be controlled by a local DDC control panel interfaced with the Building Automation System/panel controller to start, stop and reset supply water temperature. The system shall be complete with H-O-A switch and lead- lag capability accessible from local and remote terminals.

2. Whenever the H-O-A is in the "A" mode, the system shall function as follows:
   a. When the outside air temperature is below 55$^{o}$F (adjustable) the lead pump shall cycle on. When the outside air temperature rises to above 57$^{o}$F (adjustable), the lead pump shall cycle off.
   b. On proof of water flow through a differential pressure switch, the 1/3 two-way normally open/closed steam control valve shall open to maintain supply water temperature setting. If the temperature cannot be maintained, the 2/3 two-way normally open/closed steam control valve shall modulate open to maintain the

supply water set point according to reset schedule of 200°F LWT at 0°F OAT and 120°F [ °F] LWT at 50°F OAT.

c. On variation of supply water temperature plus or minus 5°F (adjustable) from the reset schedule setpoint, software in the BAS shall indicate, an alarm condition shall be indicated at the location identified by the Owner.
d. If at any time after start-up the lead pump fails to prove flow, the lag pump shall be cycled on and an alarm shall be sent to the location identified by the Owner. If at any time after start-up the lead and lag pumps fail to prove flow, all of the two-way normally open/closed modulating steam valves shall close and an alarm shall be sent to the location identified by the Owner.
e. Manual lead-lag control of the pumps shall be provided.

3. Whenever the H-O-A is in the "H" mode, the lead pump shall run continuously, the 1/3 two-way normally closed/open modulating steam control valve shall modulate open and the 2/3 two-way modulating steam control valve shall modulate open if the supply water temperature setting cannot be maintained.

4. Whenever the H-O-A is in the "O" mode, both pumps shall be off and all of the two-way normally open/closed modulating steam control valve shall be closed.

B. Reheat

1. The heat exchanger/pump assembly shall be controlled by a local DDC control panel interfaced with the Building Automation System/panel controller. The system shall be complete with H-O-A switch and lead-lag capability accessible from local/and/remote terminals.

2. Whenever the H-O-A is in the "A" mode, the system shall function as follows:
   a. The lead pump shall run continuously.
   b. On proof of water flow through a differential pressure switch, the 1/3 two-way normally closed/open modulating steam control valve shall open to maintain supply water temperature setting. If the temperature cannot be maintained, the 2/3 two-way normally closed/open modulating steam control valve shall modulate open to maintain supply water set point.
   c. On variation of supply water temperature plus or minus 5F° (adjustable) from set point software in the BAS shall indicate an alarm condition shall be indicated at the location identified by the Owner.
   d. If at any time after start-up the lead pump fails to prove flow, the lag pump shall be cycled on and an alarm shall be sent to the Engineer's office. If at any time after start-up the lead and lag pumps fail to prove flow, all of the two-way normally open/closed modulating steam valves shall close and an alarm shall be sent to the location identified by the Owner.
   e. Manual lead-lag control of the pumps shall be provided.

3. Whenever the H-O-A's in the "H" mode, the lead pump shall run continuously, the 1/3 two-way normally open/closed modulating steam control valves shall modulate to meet set point and the 2/3 two-way normally closed/open modulating steam control valve shall modulate open if the supply water temperature setting cannot be maintained.

4. Whenever the H-O-A is in the "O" mode, both pumps shall be off, and all of the two-way normally open/closed modulating steam control valve shall be closed.

## 3.5 LAB BENCH EXHAUST CONTROL SEQUENCE:

A. The ceiling exhaust control damper and the bench exhaust control damper shall be interlocked and controlled by a variable control switch, equal in function to a Johnson

Control S-224-G4. At failure, the ceiling damper shall be open and the bench exhaust damper shall be closed with revised conditions when normal control is re-established.

3.6 AIR HANDLER CONTROL SEQUENCES:

A. Air Handling Unit [____]

1. The air-handling unit shall be controlled by a local DDC control panel interfaced with the Building Automation System. The system shall be complete with access through local or remote terminals.

2. Whenever air handling unit air fan is started, the outside and exhaust air dampers shall open to their minimum positions and the supply and return/exhaust shall cycle on through an interlock.

3. The supply fan speed shall be modulated by the duct static pressure controller through the local control panel and the variable frequency drive.

4. The return fan speed shall be modulated through the local control panel and variable frequency drive to maintain a fixed (adjustable) air flow differential between supply and return air quantities as sensed by the supply and return air flow measuring stations.

5. Below an outside air temperature of 55$^{o}$F (adjustable), the outside air, return air and exhaust air dampers shall modulate to maintain a 55$^{o}$F (adjustable) mixed air set point.

6. Above an outside air temperature greater than the temperature of the return air, the dampers shall set minimum outside air conditions.

7. Under minimum outside air conditions, the damper shall modulate to maintain the constant outside air quantity as scheduled and as sensed by the outside airflow measuring station.

8. When the supply air temperature falls to below 55$^{o}$F, the preheat glycol coil pump shall cycle on and the preheating glycol normally open/closed control valve shall modulate to maintain set point.

9. When the supply air temperature rises to above 55$^{o}$F, the chilled water control valve shall modulate to meet set point.

10. When the air temperature downstream of the preheat coil is 40$^{o}$F or less, the supply and return air fans shall continue to run/cycle off, the outside air and exhaust air dampers shall close 100% and the return air damper shall open 100% coil circulating pump shall continue to run, the normally open/closed control valves shall open 100% to primary water flow and an alarm shall be sent to the and an alarm shall be sent to the location identified by the Owner.

11. On detection of smoke from the unit mounted smoke detectors or on signal from the fire alarm system, the supply and return fans shall cycle off and the outside air, return air and exhaust air dampers shall close, and an alarm shall be sent to the location identified by the Owner.

12. On detection of high static pressure in the supply air or return air ductwork, the supply and return fans shall cycle off, the outside air and exhaust air dampers shall close 100% the return air damper shall open 100% and an alarm shall be sent to the location identified by the Owner.

B. Air Handling Unit [_____]

1. The air handler shall be controlled by a DDC/local panel with a Building Management System interface.

2. Whenever the air handler is started the outside and exhaust air dampers shall open to their minimum position and the return/exhaust fan shall cycle on through an interlock.

3. The supply and return/exhaust fan speeds shall be modulated independently by respective duct static pressure controllers through the local control panel and the variable frequency drives to maintain constant scheduled supply and exhaust air quantities independent of differential pressure changes.

4. The pitch of the heat pipe heat recovery assembly shall be varied by the tilt control motor to maintain a minimum exhaust air temperature of 33 F (adjustable), and to maintain a supply air temperature of 55$^{o}$F (adjustable).

5. When the supply air temperature falls to below 55$^{o}$F, the preheat glycol coil pump shall cycle on and the preheat glycol three-way control valve shall modulate to satisfy setpoint.

6. When the supply air temperature rises to above 55$^{o}$F, the chilled water coil pump shall cycle on and the chilled water three-way control valve shall modulate to satisfy setpoint.

7. When the air temperature downstream of the preheat coil is 40$^{o}$F or less, the supply and return fans shall cycle off/continue to run and the outside and exhaust air dampers shall close 100%. The return air dampers shall open 100% and an alarm shall be sent to the location identified by the Owner.

8. Through a dry contact on the emergency power transfer switch, the power transfer switch, the BMS shall detect an emergency power condition and shall reset the supply and exhaust fan speeds through the preset speed circuit in the variable frequency drives. The speeds shall be set to maintain the scheduled minimum air quantities.

9. On detection of smoke from the unit-mounted smoke detectors or on signal from the fire alarm system, the supply and return/exhaust fans shall cycle off and the outside and exhaust air dampers shall close 100%.

10. On detection of high static pressure in the supply air return/exhaust air ductwork, the supply and return/exhaust fans shall cycle off, the outside air and exhaust air dampers shall close 100%, the return air damper open 100%, the return air damper open 100% and an alarm sent to the location identified by the Owner.

C. Air Handling Unit(s) [___]:

1. The supply fan shall run continuously with automatic start/stop capability from the DDC controlling system, and local hand-off-auto override switches at the DDC/local panel for manual operation. Red indicating pilot lights at the DDC/local panel will indicate the run status of the fan. Fan differential pressure switches will be used for proof of status.

2. The system preheat and reheat coils will be controlled by discharge air controllers/the DDC panel to maintain a coil discharge temperatures as scheduled

on the drawings. The preheat and reheat coils recirculating pumps will run when outside air temperature is below 55°F. Hand-off-auto switches at the DDC/local panel will provide manual override of the pumps if needed. Red indicating pilot lights at the DDC/local panel will indicate the run status of the pumps.

3. The evaporative cooling section shall be cycled in sequence with the outside air dampers, the chilled water cooling coil and recirculating pump as needed to maintain a system return air relative humidity set point as reset by outside air temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high limit will override all controls if the discharge humidity exceeds 60%RH (adjustable).

4. The system chilled water coil will be controlled by the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculation pump will run whenever outside air temperature is above 55°F (adjustable) or if low limit sensor senses a temperature of below 40°F (adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will indicate the run status of the pump.

5. The space relative humidity set point shall be reset from outside air temperature. Below 10°F. (Adjustable) outside air temperature, the return air humidity shall be reset from [50%RH] to [45%RH] (adjustable).

6. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.

7. On a call for cooling, the preheat and reheat coil valves shall be closed, then the evaporative cooler shall be cycled on providing the relative humidity is not holding it off. If that condition exists, the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply air temperature.

8. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the preheat and reheat valves open.

9. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the preheat and reheat valves open.

10. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.

11. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.

12. Upon the DDC system/local panel sensing the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat valves shall open.

D. Air Handling Unit(s) [_____]:

1. The return/exhaust air fans shall be interlocked to run with the respective supply air fan. The supply and return/exhaust air fans shall run continuously with automatic start/stop capability from the DDC controlling system, and have local hand-off-auto/override switches at the DDC/local panel for manual operation. Red indicating pilot lights at the DDC/local panel will indicate the run status of the fans. Fan differential pressure switches will be used for proof of status of fans.

2. The system preheat and reheat coils will be controlled by the DDC/local panel to maintain coil discharge temperatures as scheduled on the drawings. The preheat and reheat coil recirculating pumps will run when outside air temperature is below 55$^{o}$F. (Adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pumps if needed. Red indicating pilot lights at the DDC/local panel will indicate the run status of the pumps.

3. The evaporative cooling section shall be cycled in sequence with the outside air dampers, the chilled water cooling coil and recirculating pump, as needed to maintain a system return air relative humidity set point as reset by outside air temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high limit can override all controls if the discharge humidity exceeds [60%RH] [ ] (adjustable).

4. The system chilled water coil will be controlled by/from the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculating pump will only run when outside air temperature is above 55$^{o}$F. (Adjustable) or if low limit sensor senses a temperature of below 40$^{o}$F. (Adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will
indicate the run status of the pumps.

5. The return air relative humidity set point shall be reset from outside air temperature. Below 10$^{o}$F. (Adjustable) outside air temperature, the return air humidity shall be reset from [50%RH] to [45%RH] (adjustable).

6. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.

7. On a call for cooling, the preheat and reheat valves shall be closed, then the evaporative cooler shall be cycled on providing that the relative humidity is not holding it off. If that condition exists, the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply air temperature.

8. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the reheat valve open.

9. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the reheat valve open.

10. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.

11. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.

12. Upon the DDC system/local panel for each individual unit sensing that the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat coil valves shall open.

E. Air Handling Unit(s) [_____]:

1. The exhaust fans shall be interlocked to run with the supply fan. The supply fan shall run continuously with automatic start/stop capability from the DDC controlling system, and have local hand-off-auto override switches at the DDC/panel for manual operation. Red indicating pilot lights at the DDC will indicate the run status of the fans. Fan differential pressure switches will be used for proof of status of the fans.

2. The exhaust air fans will each have automatic start/stop capability from the DDC/local controller with local hand-off-auto override switches at the DDC/local panel for manual operation. In the auto position, the three exhaust fans will be staged in sequence from the position of the outside air dampers. At 60% open, the first exhaust fan will start. At 75% open the second exhaust fan will start. At 90% open the third fan will start. The set points for the three exhaust fans shall be adjustable at the DDC/local panel controller. The differential at which the fans turn off shall be adjustable at the DDC/local panel controller. Auxiliary contacts at the fan magnetic starters will be used for fan status. All fans will have on/off status at the DDC/local panel controller.

3. The system preheat and reheat coils will be controlled by the DDC/local panel to maintain a coil discharge temperatures as scheduled on the drawings. The preheat and reheat coils recirculating pumps will run when outside air temperature is below $40^{o}$F (adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC/local panel will indicate the run status of the pumps.

4. The evaporative cooling section shall be cycled in sequence with the outside air dampers and the chilled water cooling coil and recirculating pump, as needed to maintain a system return air relative humidity set point as reset by outside air temperature conditions. On a call for humidity, the outside air dampers shall be at a minimum position, and the evaporative cooler will be cycled to maintain humidity conditions. On a call for dehumidification, the evaporative cooler will be off. The outside air dampers will be modulated open providing the outside air enthalpy conditions are less than the return air conditions. If not, the chilled water coil valve will be modulated open to provide dehumidification. A discharge air humidity high

limit can override all controls if the discharge humidity exceeds [60%RH] [ ] (adjustable).

5. The system chilled water coil will be controlled by/from the DDC/local panel to modulate the three-way valve to maintain a coil discharge temperature as scheduled on the drawing. The chilled water coil recirculating pump will only run when outside air temperature is above 55°F (adjustable) or if low-limit sensor senses a temperature of below 40°F (adjustable). Hand-off-auto switches at DDC/local panel will provide manual override of pump if needed. Red indicating pilot light at DDC/local panel will indicate the run status of the pump.

6. The return air relative humidity set point shall be reset from outside air temperature. Below 10°F (adjustable) outside air temperature, the return air humidity should be reset from [50%RH] to [45%RH] (adjustable).

7. The preheat and reheat coil valves, the evaporative cooling section, and the chilled water coil valve shall all be controlled by the DDC/local panel controller to maintain a supply air temperature as determined by the outdoor and return air reset schedule.

8. On a call for cooling, the preheat and reheat valves shall be closed, then the evaporative cooler shall be cycled on providing that the relative humidity is not holding it off. If that condition exists, then the chilled water coil valve shall be opened to provide cooling. On a call for heat, the chilled water valve is closed, the evaporative cooler is off, and the preheat and reheat coil valves will be open to maintain the desired supply-air temperature.

9. In the event that humidity and temperature are below set point, the humidity control loop can have the evaporative cooler on, and the temperature control loop will have the preheat and reheat valves open.

10. In the event that humidity is above set point, and temperature is below set point, the humidity control loop can either bring in outside air, or open the chilled water valve while at the same time, the temperature control loop will have the preheat and reheat valves open.

11. In the event that humidity is below set point and temperature is above set point, the evaporative cooler will be used to try to satisfy both conditions. However, if the temperature cannot be satisfied, then the chilled water coil valve shall be controlled to help maintain temperature.

12. Outside air temperature and humidity must both be monitored with readout at the DDC/local panel. The DDC/local panel must be able to calculate the outside air wet bulb temperature with readout at the DDC panel.

13. Upon the DDC system/local panels for each individual unit sensing that the unit fan is off, the outside air dampers shall close full, the evaporative cooler shall be disabled, the chilled water valve shall close and the reheat coil valves shall open.

F. Air Handling Unit(s) [____]:

1. The supply fan(s) shall run continuously with automatic start/stop capability from the DDC/local panel controlling system, and have local hand-off-auto override switches at the DDC/local panel for manual operation. Red indicating pilot light at the DDC/local panel will indicate the run status of the fan. Fan differential pressure switch will be used for proof of status of the fan.

2. The system preheat coil shall be controlled by the DDC/local panel to maintain a coil discharge temperature as scheduled on the drawings. The preheat coil recirculating pump will only run when outside air temperature is below 55°F (adjustable). Hand-off-auto switches at the DDC/local panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC/local will indicate the run status of the pump.

3. The chilled water coil valve shall be controlled by the DDC/local panel controller to maintain a supply air temperature as determined to maintain a (65°F adjustable) room temperature. The chilled water coil recirculating pump will only run when outside air temperature is above 55°F (adjustable) or if low limit sensor senses a temperature of below 40°F (adjustable).

4. On a call for cooling, the preheat valve shall be closed, and on call for heating, the chilled water valve shall be closed.

5. Upon the DDC system sensing that the unit fan is off, the outside air damper shall close fully, the preheat coil valve shall open and the chilled water valve shall close.

## 3.7 EXHAUST FANS:

A. EF-[____]: Exhaust air fan(s) shall run continuously with manual ON/OFF control through the Building Management System [_____].

B. EF-[____]: On rise in space temperature to above the temperature set point, the intake damper shall open and the exhaust fan shall cycle on. On drop in space temperature, the reverse will occur.

C. EF-[____]: Exhaust air fan(s) shall be interlocked with the space light switch and shall run only when light switch is into ON position.

## 3.8 HOISTWAY VENTS:

A. RA-1: The normally open roof hood damper shall be closed under normal conditions. Upon smoke detection by an elevator lobby detector or power failure, the damper shall open.

## 3.9 HUMIDIFIERS:

A. AIR HANDLING UNIT [_____]:

1. On call for humidity from a system humidistat, the two-way, modulating, normally closed steam control valve shall modulate open to satisfy set point.

2. On high humidity, as sensed by a duct humidistat, the two-way modulating control valve shall close and an alarm sent to the location identified by the Owner.

## 3.10 PACKAGE TERMINAL UNITS CONTROL SEQUENCE:

A. Provide unit/wall mounted thermostat to provide automatically change over continuous fan operation during the occupied setting/cycling of the fan motor, cycling of the refrigeration system for cooling, cycling of the electric heating element for heating and night setback controls.

## 3.11 CABINET UNIT HEATERS:

A. A wall-mounted room thermostat will modulate the cabinet unit heater control valve and cycle the fan motor to maintain room thermostat temperature setting. Use pneumatic-type

thermostat to replace existing only, as pre-approved by the **LPS Operations, Maintenance and Construction (OMC) Department**.

3.12 BUILDING HOT WATER BOILERS B-_____:

A. The hot water boilers and its respective two-position control valve will be enabled from the DDC system. Each of the boilers will be sequenced on and off or opened and closed from supply water temperature as required to maintain 180°F. (Adjustable) supply water temperature. Each of the boilers internal factory mounted controls will control the firing of its own boiler. Whenever each boiler is shut off, its respective two-position control valve shall close and whenever each boiler is activated, its respective two-position control valve shall open.

B. The hot water pumps will be controlled by the DDC panel. If the lead operating pump stops, the lag pump will be started from differential pressure switch located between the discharge and suction of each pump. The lead pump will run continuously. The DDC panel will generate an alarm if the running pump stops.

C. Lead pumps will be started anytime any of the boilers are activated. The pumps shall have hand-off-auto switches and pilot light on indication at the DDC panel for easy manual override operation.

D. Building hot water supply and return temperatures will be indicated at the DDC panel.

3.13 BUILDING CHILLED WATER CHILLERS RWC-_____AND COOLING TOWERS CT-_____:

A. The chillers will be enabled from the DDC system. The chillers will be enabled above 55°F. (Adjustable) outside air temperature, or from any one of the air handling units if any one of the air handling unit sequences requires cooling or dehumidification and neither outside air intake nor the evaporative coolers can handle the requirement. Hand-off-auto switches and pilot light on indication will be provided at the DDC panel. Differential pressure switches in the chilled water and condenser water loops will not allow the chillers to start until flow has been proven.

B. The chilled water pumps and condenser water pumps will operate anytime there is a call for mechanical cooling.

C. Once the chillers have been enabled from the DDC system, each of the chillers will be controlled from their own internal factory mounted controls.

D. Chilled water supply, chilled water return, condenser water supply, condenser water return temperatures will all be indicated at the DDC panel.

E. The condenser water temperature will be controlled by the DDC system to maintain the proper condenser water temperature by cycling the cooling tower fans and modulating the two-way condenser water bypass valves.

F. Whenever the chillers are not operating or the outside air temperature is below 40°F (adjustable), the two-way condenser water bypass valve shall be closed to bypass the cooling towers and the two position condenser water return drain valve shall be opened to drain the water out of the condenser water return piping between the two position bypass valve and the cooling towers inlet piping to drain the piping exposed to outside air conditions.

3.14 DOMESTIC HOT WATER CONVERTORS:

A. Provide a temperature sensor in the domestic hot water supply water pipe from each domestic hot water convertor which shall modulate each of the normally closed two-way hot

water heating supply water/low pressure steam valves as required to maintain a domestic water supply temperature as scheduled on the drawing.

B. Domestic hot water circulating pump will run continuously. Hand-off-auto switch at the DDC panel will provide manual override of the pump if needed. Red indicating pilot light at the DDC will indicate the run status of pump.

3.15 OPERABLE GLASS CONTROL:

A. The digital controller, through single dry type contacts in the temperature control panels, shall modulate the operable sections of glass at the top of the main pyramid and the north pyramid to prevent excessive temperature or humidity levels at the top of the structure. Temperature and humidity sensors shall be located as high as possible, but below the operable sections of glass.

3.16 CHILLER ROOM VENTILATION CONTROL:

A. The exhaust air fan shall start and the outside air damper shall open any time the chiller is activated and shall run continuously until chiller is deactivated. Fan differential pressure switch will be used for proof of status of fan.

3.17 OZONE SYSTEM EMERGENCY EXHAUST FAN EF- :

A. The exhaust air fan EF- shall be interlocked with the ozone equipment room monitor system and the exhaust fan EF- shall start any time the room monitor senses an alarm condition.

**END OF SECTION 23 09 93**

# SECTION 23 20 00 - BASIC PIPING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUBMITTALS:

A. Refer to the LPS General Conditions of the Contract and Section 23 05 00 Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

C. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as follows: B31.1 - Pressure Piping Code / B31.2 - Fuel Gas Piping Code / B31.5 - Refrigeration Piping / B31.9 - Building Service Piping Code.

D. Before any welding is performed, the contractor shall submit to the Architect/Engineer, or his authorized, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests and his Welding Procedure Specification together with the Procedure Qualification Record as required by ASME Boiler and Pressure Vessel Code.

E. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.

F. Soldering and Brazing procedures shall conform to ANSI Standard Safety Code for Mechanical Refrigeration.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

C. Note: Braided metallic lines shall not be used with hydronic systems in LPS facilities.

2.2 STEEL PIPES AND PIPE FITTINGS:

A. Black Steel Pipe: ASTM A 53, Grade B, type E, electric resistance welded.

B. Galvanized Steel Pipe: ASTM A 53, Grade B.

C. Seamless Steel Pipe: ASTM A 53, Grade B, type S or A106 high temperature.

D. Stainless Steel Pipe: ASTM A 312; Grade TP 304 (high temperature and corrosive service, 1/8 inch thru 30 inches).

E. Stainless Steel Sanitary Tubing: ASTM A 270; Finish No. 80, (dairy and food industry, 1 inch thru 4 inches).

F. Steel Water Pipe: AWWA C200 for pipe 6 inches and larger.

G. Coal Tar Protective Coatings and Linings for Steel Water Pipe: AWWA C203 for enamel and tape, hot applied.

H. Chlorinated Rubber-Alkyd Paint System for Steel Water Pipe: AWWA C204 (exterior above-ground steel water pipe).

I. Cement-Mortar Protective Lining and Coating for Steel Pipe: AWWA C205.

J. Cast-Iron Flanged Fittings: ANSI/ASME B16.1, including bolting (Class 125 and 250).

K. Cast-Iron Threaded Fittings: ANSI/ASME B16.4 (Class 125 and 250).

L. Malleable-Iron Threaded Fittings: ANSI/ASME B16.3; plain or galvanized as indicated (Class 125 and 300).

M. Malleable-Iron Threaded Unions: ANSI B16.39, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal- to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).

N. Threaded Pipe Plugs: ANSI/ASME B16.14.

O. Steel Flanges/Fittings: ANSI/ASME B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.

Material Group: Group 1.1.
End Connections: Butt-welding.
Facings: Raised-face.

P. Steel Pipe Flanges for Waterworks Service: AWWA C207 (water service piping only).

Q. Corrosion-Resistant Cast Flanges/Fittings: MSS SP-51, including bolting and gasketing (threaded where pressure is not critical).

R. Forged-Steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe (up to 4 inch pipe size).

S. Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.

T. Stainless-Steel Butt-welding Fittings: MSS SP-43.

U. Cast-Iron Threaded Drainage Fittings: ANSI B16.12.

V. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.

W. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2 inches, and where pipe size is less than 1-1/2 inches, and do not thread nipples full length (no close-nipples).

2.3 COPPER TUBE AND FITTINGS:

A. Copper Tube: ASTM B 88; Type K or L as indicated for each service; hard-drawn temper, except as otherwise indicated.

B. DWV Copper Tube: ASTM B 306.

C. ACR Copper Tube: ASTM B 280.

D. Cast-Copper Solder-Joint Fittings: ANSI B16.18.

E. Wrought-Copper Solder-Joint Fittings: ANSI B16.22.

F. Cast-Copper Solder-Joint Drainage Fittings: ANSI B16.23 (drainage and vent with DWV or tube).

G. Wrought-Copper Solder-Joint Drainage Fittings: ANSI B16.29.

H. Cast-Copper Flared Tube Fittings: ANSI B16.26.

I. Bronze Pipe Flanges/Fittings: ANSI B16.24 (Class 150 and 300).

J. Copper-Tube Unions: Provide standard products recommended by manufacturer for use in service indicated.

K. Pro press vega fittings.

2.4 BRASS PIPE AND FITTINGS:

A. Red Brass Pipe: ASTM B 43 (boiler feed pipe, 1/8 inch thru 12 inches, regular or extra strong weight).

B. Cast-Bronze Threaded Fittings: ANSI B16.15, Class 125 or 250.

C. Cast-Bronze Threadless Fittings: ASTM B 61 or B 62, brazed joints.

2.5 CAST-IRON PRESSURE PIPES AND PIPE FITTINGS:

A. Ductile-Iron Pipe: Class 52, ANSI A21.51; AWWA C151; 350 psi pressure rating.

B. Cement-Mortar Lining for Ductile-Iron and Pipe and Fittings for Water: ANSI A21.4; AWWA C104.

C. Polyethylene Encasement for Ductile Cast-Iron Piping: ANSI A21.5; AWWA C105.

D. Cast-Iron Fittings: ANSI/AWWA C110/A21.10.

E. Ductile-Iron Fittings: ANSI/AWWA C110/A21.10.

F. Rubber-Gasket Joints: ANSI/AWWA C111/A21.11.

2.6 CAST-IRON SOIL PIPES AND PIPE FITTINGS:

A. Hubless Cast-Iron Soil Pipe: FS WW-P-401 and CISPI Standards 301 and 310. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.

B. Cast-Iron Hub-and-Spigot Soil Pipe: ASTM A 74. Pipe and fittings shall be marked with the collective trademark of the cast iron soil pipe institute or receive prior approval of the engineer.

C. Hubless Cast-Iron Soil Pipe Couplings: Neoprene gasket complying with ASTM C564, CISPI Standard 310 and stainless steel clamp holding band.

D. Heavy Duty Hubless Cast Iron Soil Pipe Couplings: Neoprene gasket coupling with ASTM C564. 304 stainless steel shield, minimum 0.15 inches thick, minimum 3 inches wide with 4 sealing bands up to 4 inch pipe, minimum 9 inches wide with 6 sealing bands up to 10 inch pipe.

1. Basis of Design: Husky SD 4000.

E. Cast-Iron Hub-and-Spigot Soil Pipe Fittings: Match soil pipe units; complying with ASTM A 74.

F. Neoprene Compression Gaskets: ASTM C 564.

2.7 CONCRETE PIPES AND PIPE FITTINGS:

A. Reinforced Concrete Pipe: ASTM C 76, Class 1, 2 or 3, with modified tongue-and-groove compression gasket joints complying with ASTM C 443.

B. Concrete Pipe: ASTM C 14, Class 2, unless otherwise indicated.

C. Fittings for Concrete Pipe: Match concrete pipe; provide units produced by same manufacturer, complying with same standards.

2.8 PLASTIC PIPES AND PIPE FITTINGS:

A. Acrylonitrile-Butadiene-Styrene Sewer Pipe (ABS): ASTM D-1527, 3 inch thru 12 inch; SDR 23.5, 4 and 6 inch; SDR 35, 3 inch, 4 inch, and 6 inch; SDR 42, 8 inches, 10 inch and 12 inch.

B. ABS Pipe Fittings:

Schedule 40 Socket: ASTM D 2468.
Schedule 80 Socket: ASTM D 2469.
Schedule 80 Threaded: ASTM D 2465.
Solvent Cement: ASTM D 2235.
Solvent Cement (To Join ABS To PVC): ASTM D 3138.

C. Polyvinylchloride Sewer Pipe (PVC): ASTM D-2729, 2 inch thru 6 inch; ASTM D2665, 1-1/2 inches thru 8 inches.

2.9 DRAINAGE TILE AND PIPE, FITTINGS, AND ACCESSORIES:

A. Clay Drain Tile: ASTM C 4, Standard Class, unless otherwise indicated; lengths as indicated.

B. Perforated Polyvinyl Chloride Pipe (PVC): ASTM D 2729; perforated except where standard sections of pipe are indicated.

C. Perforated Clay Pipe: ASTM C 700; Standard Strength, unless otherwise indicated.

D. Fittings and Accessories for Drainage Tile and Pipe: Unless otherwise indicated, provide fittings matching and of same material as pipe units; comply with same standards, where applicable, except fittings need not be perforated where pipe is required to be perforated.

E. Tile Joint Accessories: Where open-joint drainage tile is indicated, provide joint accessory units as follows:

1. Heavy-mesh burlap joint covers, with copper wire ties.

2. Coal-tar saturated felt covers, with copper wire ties.

3. Copper screen covers, 18-14 mesh, with copper wire ties.

4. Corrosion-resistant metal spacer-band covers.

2.10 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.

1. Comply with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials.

B. Soldering Materials: All soldering materials shall be lead free.

1. 95-5 Tin-Antimony: ASTM B 32, Grade 95TA. Melting Range 450-470 degrees F.

2. Silver-Tin Alloy: Fed. Spec. QQ-S-571E, NSFC2. Melting Range 430 to 530 degrees F.

3. Flux: All flux shall be lead free, water soluble, and compatible with the solder and the materials being joined. ASTM B813-93.

C. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.

1. Comply with AWSA 5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.

    a. Copper phosphorus -Bcup-5, 15 percent solver content, melting range 1190 to 1480 degrees F.

    b. Silver - BAg-36, 45 percent silver, cadmium-free. Melting range 1195 to 1265 degrees F.

D. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.

E. Piping Connectors for Dissimilar Non-Pressure Pipe: Elastomeric annular ring insert, or elastomeric flexible coupling secured at each end with stainless steel clamps, sized for exact fit to pipe ends and subject to approval by plumbing code.

1. Manufacturer: Subject to compliance with requirements, provide piping connectors as:

    a. Husky Technologies (Husky SD 4000):

F. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.

1. Manufacturer: Subject to compliance with requirements, provide piping thread sealant material of the following:

    a. The Rectorseal Corporation

G. Pro-press vega fittings.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, and original design, and the referenced standards.

B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.

C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16 inch misalignment tolerance.

1. Comply with ANSI B31 Code for Pressure Piping.

2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.

3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

4. Use fittings for all changes in direction and all branch connections.

5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

9. Install drains in pressure pipe systems at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾ inch ball valve, and short ¾ inch threaded end nipple and cap with chain.

10. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

11. Fire and Smoke Wall Penetrations: Where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity. Refer to Section 20 05 18 for materials.

12. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals (See Section 20 05 18.) Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.

13. Anchor piping to ensure proper direction of expansion and contraction.

14. Coordinate foundation and all other structural penetrations with structural engineer.

B. Hydronic Piping:

1. Make reductions in hydronic pipe sizes using eccentric reducer fitting installed with the level side up.

2. Install hydronic piping branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line. Install all hydronic piping level with manual air vent at all high points in direction of flow.

3. Install hydronic piping level except for gravity flow systems such as condenser water and condensate drain piping.

C. Sanitary Waste and Vent; Roof Drain and Storm Drain Piping:

1. Install plumbing drainage piping with 1/4 inch per foot (2 percent) downward slope in direction of drain for piping 3 inches and smaller, and 1/8 inch per foot (1 percent) for piping 4 inch and larger. Install cast iron pipe in accordance with the Cast Iron Soil Pipe Institute Handbook.

2. Install 1 inch thick extruded polystyrene over underground drainage piping that is above frost line and not under building. Provide width to extend minimum of 12 inches beyond each side of pipe. Install directly over pipe, centered on pipe center line.

3. Make changes in direction for drainage and vent piping using appropriate 45 degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. SANITARY CROSSES OR SHORT QUARTER BENDS SHALL NOT BE USED IN DRAIN PIPING.

4. Provide thrust restraints (bracing to structure or rodded joints) at branches and changes in direction for cast iron pipe 5inches and larger suspended within the building.

5. Where cast iron piping is suspended in excess of 18 inches on single rod hangers, sway bracing shall be provided to prevent shear at the joints.

6. Install underground drain piping to conform with the plumbing code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual.

7. Lay piping beginning at low point of system, true to grades and alignment indicated, with unbroken continuity of invert.

8. Place bell ends or groove ends of piping facing upstream.

9. Install gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements.

10. Install sub-surface drain piping according to requirements of the soils engineer’s requirements when required and connect to storm sewer / sump pump.

11. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.

12. Remove unstable, soft, and unsuitable materials at the surface upon which pipes shall be laid, and backfill with clean sand or pea gravel to indicated invert elevation.

13. Shape bottom of trench to fit the bottom ¼ of the circumference of pipe. Fill unevenness with tamped sand. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.

D. Refrigerant Piping:

1. General: Install refrigerant piping in accordance with ASHRAE Standard 15 – “The Safety Code for Mechanical Refrigeration.”

2. Install piping in as short and direct arrangement as possible to minimize pressure drop.

3. Install piping for minimum number of joints using as few elbows and other fittings as possible.

4. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

5. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

6. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

   a. Do not install insulation until system testing has been completed and all leaks have been eliminated.

7. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

8. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.

9. Slope refrigerant piping as follows:

   a. Install horizontal hot gas discharge piping with ½ inch per 10 feet downward slope away from the compressor.

   b. Install horizontal suction lines with ½ inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

   c. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

   d. Liquid lines may be install level.

E. Condensate Drain Piping:

1. Condensate drain piping from air conditioning unit coil condensate drain pan shall be of the sizes shown on the drawings.

F. Plastic Pipe:

1. All plastic piping installed below grade shall meet ASTM D2321-89 requirements.

3.3 PIPING SYSTEM JOINTS:

A. General: Provide joints of type indicated in each piping system.

B. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. Braze copper tube-and-fitting joints in accordance with ASME B31.

D. Solder copper tube-and-fitting joints with silver solder or 95-5 tin-antimony. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.

F. Weld pipe joints in accordance with recognized industry practice and as follows:

1. Weld pipe joints only when ambient temperature is above 0 degrees F (-18 degrees C) where possible.

2. Bevel pipe ends at a 37.5 degrees angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.

3. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inch to 20 inch.

4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

5. Do not weld-out piping system imperfections by tack- welding procedures; refabricate to comply with requirements.

G. Weld pipe joints of steel water pipe in accordance with AWWA C206.

H. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

I. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions. Use pre-set torque wrench set to 80 in-lbs on heavy duty couplings.

J. Clay Pipe Joints: Comply with ASTM C 12.

K. Concrete Pipe Joints: Except as otherwise indicated, comply with applicable provisions of "Concrete Pipe Field Manual" by the American Concrete Pipe Assn.

L. Corrugated Metal Pipe Joints: Comply with manufacturer's instructions and recommendations.

M. Open Drain-Tile Joints: Except as otherwise indicated, provide 1/4 inch open joint, with top 2/3 of annular space covered by joint accessory material.

3.4 PIPING APPLICATION:

A. Domestic Hot and Cold Water - Inside Building:

1. Above Grade Inside Building:

a. 6 inches and Smaller: Type L / K, hard drawn copper tube with wrought copper or bronze fittings, 95-5 tin-antimony / silver tin alloy soldered joints/pro press.

2. Below Grade Inside and Outside Building:

a. 2-1/2 inches and Smaller: Type K, soft copper or Type K annealed copper tube with wrought copper fittings, silver tin alloy solder joints.

b. Larger than 2-1/2 inches: Ductile iron, tar coated outside, cement mortar lined inside. Full lengths of pipe shall be utilized to the greatest extent possible. Fittings for ductile iron pipe shall be 350 psi pressure, tar coated outside and cement lined inside. Rubber gasket joints.

B. Sanitary Drainage and Vents - Inside Building:

1. Above Grade: Service weight cast iron, no-hub type with neoprene gaskets; service weight cast iron, hub and spigot type with neoprene gaskets; or DWV copper with wrought copper of cast brass fittings. PVC-sch 40

2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type only with neoprene compression gaskets; or sizes 12 inches and larger ductile cast iron with neoprene gasket joints. PVC-sch 40

a. Provide Husky series 4000 couplings for waste pipe above critical spaces including:

1) Food Service

2) Electrical Rooms

3) Communication Rooms

C. Sanitary Sewer - Beyond 5 feet Outside Building: PVC-sch 40; sizes 12" and larger ductile cast iron with neoprene gaskets; or service weight cast iron, hub and spigot type with neoprene gaskets.

D. Roof Drainage - Inside Building:

1. Above Grade:

a. 30 foot head or less: Service weight cast iron, hub and spigot type or no-hub Husky Series 4000 (or equivalent); or galvanized steel with galvanized cast iron drainage fittings and threaded joints. PVC-sch 40

b. Over 30 foot head: Schedule 40 galvanized steel pipe with galvanized cast iron drainage fittings and threaded joints; or schedule 40 grooved galvanized steel pipe joined with rigid couplings and gaskets designed for water service, molded of materials conforming to ASTM D-2000; or ductile iron, thickness 52 or ANSI/AWWA C150/A21.50-81, 350 psi pressure rating. Full lengths of pipe shall be utilized to greatest extent possible. PVC-sch 40.

2. Below Grade: Sizes 2 inch to 20 inch, service weight cast iron, hub and spigot type or sizes 12 inches and larger ductile cast iron with neoprene gasket joints. PVC SDR 35.

E. Storm Sewer - Beyond 5 feet Outside Building: ASTM D3034 SDR-35 PVC sewer pipe, sizes 12 inches and larger ductile cast iron with neoprene gasket joints; or service weight cast iron, hub and spigot type with neoprene gaskets.

F. Accessible Gas Piping:

1. Above Grade:

a. Exposed Location:
   1) Inches and Smaller: Schedule 40, black steel pipe, beveled ends, with 150 lb. malleable iron fittings and threaded joints.
   2) Over 2 Inches: Schedule 40 black steel with butt weld fittings and welded joints.

b. Inaccessible Location:
   1) All sizes: Schedule 40 black steel pipe, beveled ends, with socket weld fittings same thickness as pipe; welded joints.

2. Below Grade: Schedule 40 seamless black steel with 150 lb. forged steel fittings and welded joints. Provide machine applied, coated and wrapped pipe in accordance with local code and utility company requirements. Provide cathodic protection as called for on the drawings.

G. Heating Water, Chilled Water and Condenser Water Piping:

1. 2 Inches and Smaller:

   a. a. Schedule 40, black steel with 125 lb. cast iron or 150 lb. malleable iron threaded fittings.

   OR

   b. Type L / K copper, hard drawn copper wrought copper or bronze fittings, silver-tin alloy solder joints.

2. 2-1/2 Inches and Larger:

   a. Schedule 40, seamless or ERW (std. weight 12 inches and over) black steel with flanged or welded joints.
   b. Fittings: Standard weight / Extra strong, seamless steel, butt weld type.
   c. Flanges: 150 lb. 300 lb. forged steel slip-on or welding neck type.
   d. Bolting: Regular square head machine bolts with heavy hexagonal nuts.
   e. Gaskets: Thickness, material and type suitable for fluid to be handled, and design temperature and pressures.

3. Buried Piping:

   a. Provide pre-insulated, pre-fabricated piping. Refer to Section 15070 / 15080.

H. Equipment Drains and Overflows:

1. Type “M” or “DWV” copper. PVC-sch 40.

I. Sub-Surface Drain Pipe:

1. ASTM D3034 SDR-35 Polyvinylchloride (PVC) perforated sewer pipe.

OR

2. BS corrugated, perforated polyethylene under drain pipe.

J. Refrigerant Piping:

1. Type “L” ACR copper, cleaned, dehydrated and capped at the factory. Wrought copper fittings with brazed joints.

K. Sump Pump Discharge:

1. Schedule 40 PVC.

2. Type L, seamless, hard drawn copper tube with ANSI/ASME B16.22 wrought copper or bronze solder-joint pressure fittings.

L. Engine Generator Exhaust:

1. Schedule 40 (std. weight 12 inches and over), black steel with all welded joints.

M. Fuel Oil Piping:

1. Refer to other Division 20 through 22 sections – Fuel Oil Systems.

3.5 PIPING TESTS:

A. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

B. Test all piping systems as specified. Correct leaks by remaking joints. Remove equipment not able to withstand test procedure during test.

C. Work to be installed shall remain uncovered until the required tests have been completed.

D. Piping which is to be concealed shall be tested before being permanently enclosed.

E. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.

F. Give a minimum of twenty-four hours' notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of owner, agency having jurisdiction or his representative. Submit three (3) copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

G. Contractor shall obtain certificates of approval, acceptance and compliance with regulations of agencies having jurisdiction. Work shall not be considered complete until such certificates have been delivered by the Engineer to the Owner.

H. All costs involved in these tests shall be borne by Contractor.

I. System Tests

1. Hydrostatic Test: The test shall be accomplished by hand pumping the system to the specified water pressure, and maintaining that pressure until the entire system has been inspected for leaks, but in no case for a time period of less than four hours.

a. Domestic water systems: 100 psig or 150 percent of system pressure, whichever is greater.
b. Heating water: 100 psig or 150 percent of operating pressure, whichever is greater.
c. Chilled water: 100 psig or 150 percent of system pressure, whichever is greater.
d. Condenser water: 100 psig or 150 percent of system pressure, whichever is greater.

2. Compressed Air or Nitrogen Test: Compressed air tests may be substituted for hydrostatic tests only when ambient conditions or existing building conditions prohibit safe use of hydrostatic testing and must be reviewed by the Engineer prior to any testing. For tests of this type, the piping system shall be subjected to the gas pressure indicated for that specific system. The piping capped or plugged and water-pumped with oil-free air, or a nitrogen bottle shall be introduced into the entire system to the pressure specified. The system shall maintain that pressure for the duration of a soapy water test of each joint.

3. Waste, Drain and Vent Piping: All waste and vent piping, including building drain, roof drain and building sewer, shall be subjected to a water test. All openings in the piping system shall be tightly closed, except the highest opening, and the system filled with water to the point of overflow. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before inspection starts; the system shall then be tight to all points. No section shall be tested with less than a ten foot head of water. Roof drain shall be closed at the lowest point and filled with water to the point of overflow.

4. Sump Pump Discharge: With water in sump and pump running at full capacity, check for leaks until satisfied that system is tight.

5. Test all refrigerant piping systems with nitrogen at 300 psig pressure on high side of the system, and at 150 psig pressure on low side of system. Maintain pressure without loss for a time period of not less than 4 hours. After test has been completed, the piping shall be evacuated by means of a vacuum pump for a period of not less than 24 hours or until system has been completely evacuated.

6. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

7. Drain test water from piping systems after testing and repair work has been completed.

3.6 UNDERGROUND PIPE INSTALLATION:

A. Clean fittings, nipples and other field joints thoroughly before coating.

B. Protect gray and ductile cast iron pipe installed below grade with polyethylene encasement applied in strict accordance with ANSI/AWWA C105/A21.5.

C. Install ductile iron pipe below grade as prescribed by AWWA C600.

D. Provide concrete thrust block and 3/4 inch steel threaded tie bar at each direction change on underground pressure pipe. Imbed tie bar in thrust block and connect to upstream fitting. Paint tie bar with two coats of bitumastic #50 paint.

E. Bury all outside water piping minimum 5 feet-0 inches [ ] below grade to top of pipe.

3.7 ADJUSTING AND CLEANING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Disinfect all potable water mains and water service piping in accordance with local and health department requirements. Submit test results report.

C. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

D. Chemical Treatment: Provide hydronic systems with a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.8 COMMISSIONING:

A. Fill system and perform initial chemical treatment.

B. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.

C. Before operating the system perform these steps:

1. Open valves to full open position. Close coil bypass valves.

2. Remove and clean strainers.

3. Check pump for proper rotation and proper wiring.

4. Set automatic fill valves for required system pressure.

5. Check air vents at high points of systems and determine if all are installed and operating freely (automatic type) or to bleed air completely (manual type).

6. Set temperature controls so all coils are calling for full flow.

7. Check operation of automatic bypass valve.

8. Check and set operating temperature of boilers, chillers, and cooling towers to design requirements.

9. Lubricate motors and bearings.

**END OF SECTION 23 20 00**

# SECTION 23 21 13.13a - UNDERGROUND PIPING FOR SYSTEMS BELOW 250° F

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies piping materials and installation methods common to this section of Divisions 20 through 25 and includes joining materials, piping specialties, and basic piping installation instructions for all soil conditions.

1.2 REFERENCES:

A. ANSI B31.1

1.3 SUBMITTALS:

A. Refer to the LPS General Conditions of the Contract and Section 23 05 00 Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

1.4 QUALITY ASSURANCE:

A. System shall be factory tested and inspected in accordance with manufacturer's requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Comply with governing regulations and industry standards.

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1 Perma-Pipe/Ricwil
2 Thermal Pipe Systems
3 Thermacor

2.2 UNDERGROUND CHILLED WATER SUPPLY AND RETURN PIPE:

A. The underground piping shall be a pre-insulated polyurethane piping system composed of [Schedule 40 ASTM A-53 or A-106, grade B carbon steel pipe] [SDR-26 class 160 PVC pipe],

[Type L/K copper] [schedule 40 solvent weld PVC pipe] Carrier pipe, 2 inches of polyurethane insulation and a [high density polyethelene], [PVC] [Fiberglass] outer casing. Fittings shall be of compatible material and size.

PART 3 - EXECUTION

3.1 EXCAVATION AND BACKFILLING:

A. Excavation and backfill shall be in accordance with Divisions 2, 20 through 25, 31 and 33 and the pipe system manufacturer's recommendations.

3.2 UNLOADING, HANDLING, ASSEMBLY AND INSTALLATION:

A. The unloading, handling, assembly and installation of the system shall be done in accordance with the instructions in the manufacturer's installation guide, and as further supplemented by instructions of the manufacturer's representative at the job site. Such representative shall be present during the job installation, testing, system turn-on, and as requested by the Contractor or Engineer.

3.3 TESTING:

A. Testing work shall be done under the supervision of a manufacturer's representative.
B. Piping shall be hydrostatically tested in the field under pressure of 150 psig.
C. Joints in the outer casing shall be tested to show ground water will not leak into the piping system.

**END OF SECTION 23 21 13.13a**

# SECTION 23 21 13.13b - UNDERGROUND PIPING FOR CLASS A SOILS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies piping materials and installation methods common to this section of Divisions 20 through 25 and includes joining materials, piping specialties, and basic piping installation instructions for poorly drained soils subject to prolonged saturation.

1.2 REFERENCES:

A. ANSI B31.1

B. Federal Agency Guideline Specifications FCGS 15705.

1.3 SUBMITTALS:

A. Refer to the LPS General Conditions of the Contract and Section 23 05 00 Basic Mechanical Requirements for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

1.4 QUALITY ASSURANCE:

A. System shall be factory tested and inspected in accordance with the manufacturer's requirements.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards.

C. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers listed.

1. Perma-Pipe/RicWil

2.2 DESCRIPTION :

A. The pre-fabricated underground heat distribution system specified herein shall be chemically bonded urethane coated, air pressure testable, drainable and dryable, steel conduit type system for [15] [ ] psig steam and high temperature water service. The condensate return system shall either be identical to the steam system, or shall be a direct buried, reinforced thermosetting resin plastic pipe system conforming to NAVFAC Specification TS 15707, whichever is required by the contract specifications.

2.3 USAGE:

A. The system specified herein shall be intended for use in Class A (underground water conditions) sites and in corrosive soil conditions as defined in FCGS Specification 15705. It is also qualified for use in Class B, C and D sites as specified in FCGS Specification 15705. Cathodic protection shall be provided.

2.4 MATERIALS:

A. All components and materials shall conform to specifications, drawings, manufacturer's letters and tables hereinafter specified. Referenced Federal and Military Specifications and Industry Standards are specified by basic designation only.

2.5 REFABRICATED COMPONENTS:

A. Materials and coatings for prefabricated components shall be as specified in Paragraph 2.6 "Materials."

B. Straight conduit sections shall be factory coated as specified hereinafter. Straight sections shall be fabricated in 40 foot nominal length with five pipe supports as indicated; shorter lengths shall be fabricated with supports not more than nine feet apart and with a pipe support not more than two feet from each end.

C. Terminal sections shall be identical to straight sections except that they shall be prefabricated with leak plates and seals as follows, and shall be provided with a minimum one inch vent (open) and minimum one inch drain half coupling (threaded) fitted with a threaded forged steel plug.

1. Leak plates shall be of 120 gauge steel plate conforming to ASTM A-36.

2. End seals shall be of 1/4 inch steel plate conforming to ASTM A-36.

3. Gland seals shall consist of a steel closure plate with stainless steel bolts and a steel gland welded thereto a temperature resistant2teflon impregnated asbestos packing gland and a gland follower.

D. Expansion loops shall be properly engineered and designed in accordance with the allowable stress limits indicated by ANSI B31.10 for the type of pipe used. Expansion loops shall consist of conduit composed of the same material and the same coating as the straight run conduit and sized to accommodate anticipated expansion. Decreaser conduit connections and thicknesses for two piece type and expansion type loops together with expansion type pipe supports shall be provided. End width shall be sized according to field/jobsite conditions.

E. Pipe supports shall be of the type where calcium silicate pipe insulation thermally and electrically isolates the pipe from outer conduit. Direct contact with support and pipe will not be allowed.

F. Elbows shall be of either the anchor or expansion type.

G. Anchor sections shall be 1/4 inch steel plate conforming to ASTM A-36 steel.

2.6 MATERIALS:

A. Casing for all components shall be either electric resistance welded or spiral welded steel pipe conforming to ASTM Specifications A-211, A-134 and A-135.

B. Coating:

1. Outside casing shall be factory coating with a chemically bonded urethane or fully impregnated fiberglass cloth with multiple pass epoxy resin (450-525 epoxide equivalent). Coating application shall be a minimum of 30 mill thickness and as specified in the Quality Control Section. Coating shall pass 100 percent holiday testing at 5000 volt spark level.

2. Field joints shall be coated with chemically bonded polyurethane or shrink sleeves. Field joint application shall be as specified in the Quality Control Section.

3. Factory fabricated fittings shall be factory coated on the outside with the coating specified above for outside casings. Factory fittings application shall be as specified in the Quality Control Section.

4. End seals and other steel surfaces except anchor plates shall be coated using chemically bonded polyurethane. Coating application shall be as specified in the Quality Control Section.

C. Anchor plates and miscellaneous steel parts shall be ASTM A-36 steel unless otherwise specified hereinafter.

2.7 CATHODIC PROTECTION SYSTEMS:

A. General

1. Cathodic protection against galvanic corrosion shall be provided for the underground conduit system. The cathodic protection system shall be as shown on the contract drawings.

2. Installation of cathodic protection system shall be in strict accordance with the recommendations of and under the direct supervision of the conduit manufacturer, including anodes, conductors, isolation, splices, electrical connections to conduit and test stations.

B. Scope of Work:

1. Supply all manpower, tools, equipment and transportation to complete the cathodic protection installation.

2. The installation shall include, but not be limited to, the following:

a. Installation of all magnesium anodes, and anode collector cable.

b. Supply an attachment of test cables to conduit and magnesium anodes.

c. Supply and installation of test stations as shown.

d. Testing of the system as outlined in the Nace Recommended Practice RP-01-69 (Latest Revision). All tests shall be made by a Nace accredited corrosion specialist or a representative under his direct supervision.

e. The cathodic protection system shall be tested within six months of completion of backfilling, by a "corrosion Specialist" as certified by the National Association of Corrosion Engineers or his authorized representative.

f. Cathodic protection test instrument shall be furnished by the Owner.

C. Magnesium Anodes:

| COMPOSITION | PERCENT BY WEIGHT |
|---|---|
| Aluminum | 5.300 – 6.700 |
| Zinc | 2.500 – 3.500 |
| Manganese (Min.) | 0.150 |
| Iron (Max.) | 0.003 |
| Nickel (Max.) | 0.002 |
| Copper (Max.) | 0.020 |
| Silicon (Max.) | 0.100 |
| Other (Max.) | 0.300 |
| Magnesium | Remainder |
| Total Anode Weight | 17 lbs |

1. All anodes shall be cast with a perforated galvanized steel strap core. The anode lead wire shall be connected to the strap core with cadmium weld connection. The connection shall be mechanically secured before soldering with at least 1-1/2 turns of wire at the connection. The connection shall be insulated by filling the anodes recess with an electrical potting compound.

2. The anode shall be packaged in a permeable cloth bag containing a backfill of the following composition:

| | |
|---|---|
| Ground Hydrated Gypsum | 75% |
| Powdered Wyoming Bentonite | 20% |
| Anhydrous Sodium Sulfate | 5% |

3. Backfill shall have a grain size so that 100 percent is capable of passing through 100 mesh screen. The mixture shall be firmly packaged around the magnesium anode within the cloth bag by means of adequate vibration so that the anode is completely surrounded with a minimum of 1/2 inch of backfill material.

D. Conductors – Anode conductor or lead wire shall be #12 type TW solid copper wire, unless otherwise shown on drawings.

E. Cartridge size and alloy type shall be #CA-15 cartridge and F-33 alloy. Wires connected to the piping system for test purposes shall be not less than #12 type TW. Anode wires shall be spliced to a common or gathering cable. The cable size shall be #8 type CP (HMWPE) stranded copper wire suitable for direct burial.

F. Electrical Isolation – Piping shall be electrically isolated from internal building piping at the point of connection inside the building. Dielectric flanges shall be installed on each pipe and the conduit shall be isolated from the building wall with a wall sleeve and neoprene link seal.

G. Underground Cable Splices – All underground splices shall be made using copper compression bolts. All splices shall be moisture-proof.

H. All electrical wire connections to the conduit shall be made using the thermit welding process.

I. Electrical Isolation – It shall be the responsibility of the contractor installing the underground conduit and related piping to prevent shorting of the system to building steel, reinforcing steel in building, foundations and other buried metallic structures.

J. Test Stations:

1. Test Stations shall be provided where shown on contract drawing for the purpose of testing the performance of the cathodic protection system. Test leads terminating in test stations shall have a minimum of 18 inches of slack lead below grade. Test leads shall be housed in electrical conduit and shall terminate in waterproof junction boxes.

2.8 SPECIAL STRUCTURAL ELEMENTS:

A. Special structural elements for unstable soils and super- imposed loads shall be designed as required for the application and submitted for approval.

2.9 CONCRETE:

A. Concrete for anchor blocks and flotation pads shall be 3,000 pound minimum strength concrete conforming to ACI 2.11 1-74.

2.10 MANHOLES:

A. Manholes shall be pre-cast concrete type.

B. Manhole dimensions shall be as indicated on drawings and in all cases shall provide sufficient room for maintenance.

C. Manhole ladders shall have non-slip surface and shall consist of uprights and steps or rungs or of full U-shaped rungs firmly embedded in concrete sidewalls. Uprights shall be firmly anchored to the manhole walls. All parts shall be treated for corrosion protection.

D. Piping and equipment in manholes shall be installed so as to provide easy access without stepping on piping or equipment and to provide sufficient working room. Piping in manholes shall rest on suitable sidewall or floor supports equipped with cast iron rollers.

PART 3 – EXECUTION

3.1 INSTALLATION SPECIFICATION:

A. A fully qualified and certified factory representative shall be present during all crucial periods of the installation of the underground heat distribution system. Crucial periods of the installation shall be defined as periods which include one or more of the following types of work.

1. Inspection and unloading.
2. Inspection of trench prior to laying of conduit.
3. Inspection of concrete thrust blocks prior to cold springing.
4. Cold springing.
5. Hydrostatic test of all service lines.
6. Field joint closure work.
7. Air test of conduit.
8. Repair of any coating patch work.
9. Holiday test of conduit coating.
10. Initial backfill up to 10 inches above the top of the conduit casing.

B. The representative shall see that all damaged material is repaired or replaced as required by the contract documents, including the quality control requirements of this specification.

C. Detailed Specifications:

1. Unloading - Materials shall be unloaded with a padded sling. Long conduit sections, manholes and expansion loops, etc. shall be unloaded with a spreaderbar type hoist having two or more slings.
2. Storage - System sections shall be stored and blocked with 2 inches x 4 inches on 8 foot centers. System sections shall be stored with end seals in place. Each system section shall be checked to ensure that any end cover removed for inspection of inside of conduit line has been properly replaced.
3. When insulation accidentally becomes wet at any time before or during installation, the air space in the system shall be force ventilated at a rate of not less than 2 CFM, and heat shall be applied through the internal piping. A cool mirror shall be placed at the exhaust point for a short time at appropriate intervals and shall be so positioned as to indicate maximum fogging due to moisture. The ventilation shall continue until the mirror exhibits no visible fogging.
4. Inside shall be inspected for mud or other blockage of drainage. If blockage or mud is found, the component shall be flushed out with water before drying. If the blockage cannot be flushed so as to ensure proper drainage, the component shall be rejected and a new one provided.
5. Trenching shall be to the depth indicated on the drawings. Trench widths in stable soil shall be as indicated on drawings. For unstable soil, high or low PH or other unusual soil conditions, trenching shall be as specified by the engineer. Trenches shall be kept dry and excavated soil shall be placed so as to prevent rain runoff from entering trench. Grading shall be checked to ensure correct pitch of lines. Trench bottoms for FRP pipe in stable soils shall be bedded with three inches of fine granular fill. For trench bottoms in unstable soil, the bedding shall be determined by the engineer.

6. Welding in trenches - System end covers and shipping tie rods shall remain in place until welding operations are ready to commence. Welding in trenches shall be minimized. System sections including loops and ells shall be first laid out, aligned and welded above the trench. Prior to welding a check shall be made to ensure pipe and expansion supports are aligned and true. The initial 15 psi conduit pressure test shall also be accomplished on as long a connected system above the trench as possible; then the completed and tested sections lowered and positioned in the trench.

7. Factory representatives shall ensure that welding is properly done and tested as follows:

    a. Conduct test of the welding procedure used to determine its suitability to ensure welds will meet the required tests and conduct tests of the welders to ensure their competence to make quality welds under standard conditions. Radiographic examination of welds may be required to ensure quality welds.

    b. Be thoroughly familiar with the requirements of ANSI B31.1 and American Welding Society Standard B3.0.

    c. Be capable of performing all welding operations required for construction and installation of the heat distribution system.

8. Lowering Conduit Sections into Trench - Conduit sections whether or not welded and tested above ground shall be lowered with slings, etc. Remove end covers and remove shipping tie rods when necessary for installation. Place only the amount of conduit in trench that can be tested, field closed and coated in one day. If any ends or joints are uncovered at the end of the day or during rain, they shall be waterproofed, sealed and recovered to prevent moisture. If internal moisture is detected they shall be dried as specified in paragraph 4 of the preceding Installation Specifications.

9. Expansion Loops and L and Z Bends and Elbows shall be sloped to drain to the straight runs. Pipe supports, expansion loops, reducers, etc. shall be properly aligned and positioned for a true fit.

10. Cold Spring - All piping systems shall be cold spring 1/2 the total calculation expansion of the system. Angle clips shall then be welded on the ends of the adjusted pipes. Then a single threaded rod shall be placed through the holes in the clips and tightened until the pipes are aligned. The pipes shall then be welded as specified in ANSI B31.1.

11. Hydrostatic tests of service piping - All service piping shall be tested hydrostatically before insulation is applied at field joints, and shall be proved tight at a pressure 100 psig. Hydrostatic test pressure shall be tested before conduit field joints are insulated and closed. Prior to the hydrostatic, performance and operating tests, the interior of the heat-carrying piping shall be flushed with water until the piping is free of all foreign materials to the satisfactory of the Engineer.

12. Casing Field Joints:

    a. Insulation - Insulation shall be banded on pipe with stainless steel bands maximum of 18 inches on center. At field joints insulation shall be grooved to fit over welded pipe.

    b. Field joint shall be accomplished by cleaning to bare metal the conduit section to be joined, banding tightly the steel sleeve over the conduit, welding both sleeve collars and horizontal sleeve lap, then apply the chemically bonded polyurethane.

13. Final inspection and test before backfill - The completed system shall be visually inspected for blisters, loose coating, damage, etc.; spark tested and sections repaired or replaced in accordance with the Quality Control Section of this specifications.

14. Cathodic protection shall be installed before backfilling.

15. Final testing after backfilling shall be performed in accordance with the Quality Control section of this specification. Any repairs or replacements necessary will be at the contractor's or manufacturer's expense.

3.2 QUALITY CONTROL:

A. Factory - All factory fabrication at either the jobsite plant or the home office plant shall be overseen, inspected, tested and accepted or rejected by the Factory Quality Control Section.

1. Welding shall be by qualified welders and shall be performed and inspected in accordance with ANSI B31.1.

2. Conduit components shall be coated as follows:

a. 1.2.1 Outer casing

1) Clean to bare metal by shot or sand blasting, mechanical wire brushing or mechanical sanding.

2) Factory applied polyurethane coating.

b. All other components and steel parts shall be cleaned to bare metal as specified in Section C, Hardware Specifications.

3. Inspection - All conduit, assemblies and other components shall be carefully inspected to insure that coating is solid and firmly bonded and that dimensions are correct. All insulation shall be inspected for thickness and correct banding, including banding spacing and snugness.

4. Testing - All exterior steel casing parts shall be spark tested at a voltage of 1250 times the square root of the average coating thickness in mils plus/minus 5 percent with an approved calibrated spark tester.

5. All casings including fittings and preassembled units shall be air pressure tested at 15 psig for a period of not less than two hours.

6. All expansion loops and elbows and straight runs connecting thereto shall be checked for correct alignment of expansion guides and marked to assure assembly in correct position.

7. Storage in stockpile shall be as follows: Store with shipping tie rods (conduit to pipe ends) and end covers firmly in place to prevent water entry, all as described in paragraph 3 of Installation Specifications.

8. The Quality Control Section shall oversee removal from stockpile and proper loading and blocking, etc., for shipment.

B. Field Inspection and Testing:

1. Visual Inspection - Each section of conduit, fittings and batch of material shall be visually examined and measured, where necessary, to determine shipping damage, thickness of coating, required air space, bond of coating to conduit and other evidence of conformance or non-conformance to the requirements of these specifications. Any conduit section, fitting or batch of material which does not conform to these requirements or which shows shipping damage beyond that permitted by the paragraph on holiday testing shall be rejected without further examination or test. End covers removed for inspection shall be carefully and securely replaced.

2. Holiday Detector Test - After visual examination and prior to installation in the trench, holiday detector tests shall be performed on the exterior of the first five sections and every tenth section thereafter of coated metallic conduit. If it is found that the factory applied waterproofing material is inadequate, the section shall be rejected and every section of the uninstalled material on the jobsite and all material delivered thereafter shall be holiday tested. The tests shall be accomplished with silicone rubber electric wirebrush, or a coil probe testing set with an operating bell, buzzer or other audible signal. The tester shall be a type so fixed that field adjustment cannot be made. Calibration by the manufacturer of the tester shall be performed at six-month intervals or at such times as crest voltage is questionable. The manufacturer of the test shall certify in writing the date of calibration and crest voltage setting. The battery shall be maintained at ample charge to produce the crest voltage during all tests. If voids detected by either visual examination or by holiday test of any section were obviously caused by improper banding, and are such that the areas of patches extending a minimum of two inches from the outer periphery of the voids will total less than 100 square inches, for sections 20 feet of less in length, or less than 200 square inches for sections approximately 40 feet in length, the sections may be repaired. The repair shall be effected by using material identical to that or the original coating or that being used for field joints shall be accomplished to the satisfaction of the Engineer. The repaired section shall be tested to prove that there are no holidays evident before installation. When more than the above specified area of any section of coated conduit fails to meet the first holiday test, that section shall be removed from the jobsite and replaced with new materials. After installation of conduit and prior to backfilling, the waterproofed exterior surfaces, including completed field joints of the conduit, shall again be tested for holidays. Any of the conduit, shall again be tested for holidays. Any holidays revealed shall be promptly repaired to a condition as good as the rest of the system, or the conduit section shall be replaced.

    a. Coating repair procedure when repair permitted. Clean coating down to bare metal and apply by smoothly brushing chemically bonded polyurethane.

3. Examination of welds on pipe - All pipe welds shall be inspected in accordance with ANSI B31.1.

4. Air pressure test of sections in trench before backfill - All conduit casing shall be proved tight after installation, and before applying field joint waterproofing and before backfilling by the application of an internal air pressure of 15 psig, for a period of not less than one hour without any additional air being supplied. All joints shall be tested with an application of soap and water solution. All leaks located shall be repaired and retested until proven tight. Repairs to metallic casings shall be made by welding.

5. Holiday detector test before backfill. After assembly in trench and before backfill, the sections to be backfilled shall be holiday detector tested and repaired or replaced as necessary.

6. Hydrostatic test of system - After completion the entire system shall be flushed and hydrostatic tested. Any leaks shall be repaired and the entire test sequence repeated on the leaking section.

7. Final air pressure test after backfill manhole to manhole - After completion of the entire system or section between manholes the 15 lb. air pressure test shall be applied manhole to manhole for a period of not less than one hour.

8. Operational Tests - After completion of the system, or testable portions thereof, operational tests shall be conducted as in service to demonstrate satisfactory function and operation effectiveness. The tests on each system, or portion thereof, shall last not less than six hours.

**END OF SECTION 23 21 13.13b**

# SECTION 23 21 16 - PIPING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division 20 through 23 sections.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".

2. ASME B 31.9 "Building Services Piping" for materials, products, and installation.

3. Safety valves and pressure vessels shall bear the appropriate ASME label.

4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

5. ASME “Boiler and Pressure Vessel Code”, Section IX, “Welding and Brazing Qualification” for qualifications for welding processes and operators.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

D. A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Combination Pressure and Temperature Relief Valves:
    a. Watts Regulator Co.
    b. McDonnell & Miller, Inc.
    c. Amtrol, Inc.
    d. Bell & Gossett ITT; Fluid Handling Div.
    e. Spirax Sarco
2. Pressure Reducing Valves:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Taco, Inc.
    c. Watts Regulator Co.
    d. Amtrol, Inc.
    e. Armstrong Pumps, Inc.
    f. Keckley
3. Air Vents:
    a. Armstrong Machine Works
    b. Bell & Gossett ITT; Fluid Handling Div.
    c. Hoffman Specialty ITT; Fluid Handling Div.
    d. Spirax Sarco
    e. Amtrol, Inc.
4. Air Separators:
    a. Bell & Gossett ITT; Fluid Handling Div.
    b. Taco, Inc.
    c. Wilkerson
    d. Amtrol, Inc.
    e. Armstrong Pumps, Inc.
    f. The John Wood Co.
5. Air Eliminator
    a. Spirotherm, Inc.
6. Air Eliminator and Dirt Separator
    a. Spirotherm, Inc.
7. Compression Tanks:
    a. Amtrol, Inc.
    b. Armstrong Pumps, Inc.
    c. Bell & Gossett ITT; Fluid Handling Div.
    d. Taco, Inc.
    e. The John Wood Co.
8. Diaphragm-Type Compression Tanks:
    a. Amtrol, Inc.

b. Armstrong Pumps, Inc.
c. Bell & Gossett ITT; Fluid Handling Div.
d. Taco, Inc.
e. The John Wood Co.
f. Wessles

9. Pump Suction Diffusers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Taco, Inc.
   e. Victaulic Company of America
10. Automatic Flow Control Valves:
   a. Griswold
11. Hydronic System Safety Relief Valves:
   a. Watts Regulator Co.
   b. McDonnell & Miller, Inc.
   c. Bell & Gossett ITT; Fluid Handling Div.
   d. Kunkle Valve Co., Inc.
   e. Lunkenheimer Co.
   f. Lonergan
   g. Keckley
   h. Conbraco
12. Pressure Regulating Valves:
   a. Bell & GossetA.W. Cash Valve Mfgr. Corp.
   b. Taco
   c. Watts Regulator Co.
   d. Armstrong Machince Works, A-Y Division
   e. Fisher Constrols International, Inc.
   f. Hoffman Specialty ITT; Fluid Handling Div.
   g. Leslie Co.
   h. Spirax Sarco
   i. Spence Engineering Co., Inc.
   j. Wilkins Regulator, Div Zurn Industries Inc.
13. Pipe Escutcheons:
   a. Chicago Specialty Mfg. Co.
   b. Producers Specialty & Mfg. Corp.
   c. Sanitary-Dash Mfg. Co.
14. Low Pressure Strainers:

a. Armstrong Machince Works, A-Y Division
b. Hoffman Specialty ITT; Fluid Handling Div.
c. Metraflex Co.
d. R-P&C Valve; Div. White Consolidated Industries, Inc.
e. Spirax Sarco
f. Trane Co.
g. Victaulic Co. of America
h. Watts Regulator Co.

15. High Pressure Y-Type Strainers:
    a. Armstrong Machince Works, A-Y Division
    b. Hoffman Specialty ITT; Fluid Handling Div.
    c. Metraflex Co.
    d. R-P&C Valve; Div. White Consolidated Industries, Inc.
    e. Spirax Sarco
    f. Trane Co.
    g. Watts Regulator Co.
16. Basket Strainers:
    a. R-P&C Valve
    b. Keckley
17. Dielectric Waterways (Note: limited use, only with approval by the LPS Operations, Maintenance and Construction (OMC) Department):
    a. Victaulic Co.
    b. Perfection Corp.
    c. Flow Design Inc.
    d. Rockford-Eclipse Div.
18. Mechanical Sleeve Seal:
    a. Thunderline Corp.
    b. Metra Flex

2.2 HYDRONIC PIPING SPECIALTIES:

A. General: Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

B. Hydronic System Safety Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure to suit system and have the capability for field adjustment. Safety relief valve shall be designed, manufactured, tested and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250 degrees F maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Set valve to relieve at 10 psi above operating pressure.

C. Pressure Reducing Valves: Diaphragm operated, bronze or brass body valve, with low inlet pressure check valve, stainless steel inlet strainer removable without system shut-down, and stainless steel valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.

D. Coin Operated Manual Air Vent: Bronze body and nonferrous internal parts; 150 psig working pressure, 212 degrees F operating temperature; manually coin operated and having discharge outlet connection and 1/8 inch NPT male connection.

E. Manual Air Vent: Provide ball valves as specified in Part 3.

F. Automatic Air Vent: 100 psi working pressure, 240 degrees working temperature, stamped brass body and non-metallic float, with threaded outlet connector for "safe waste" discharge pipe.

1. Amtroll 703 or approved equivalent

G. High Capacity Automatic Air Vent: 150 psig working pressure, 250 degrees working temperature, cast iron body, bronze pilot mechanism. Snap acting operation, preventing opening under negative pressure conditions. Capable of 18 scfm elimination at 30 psig.

1. Amtroll 720 or approved equivalent

EDIT NOTE: Traditional Air Separator

H. Air Separators: Welded black steel; ASME constructed and labeled for minimum 125 psig water working pressure and 350 degrees F operating temperature; perforated stainless steel air collector tube; tangential inlet and outlet connections; screwed connections up to and including 3 inch NPS; flanged connections for 4 inch NPS and above; threaded blowdown connection; sized as indicated for full system flow capacity.

I. Air Eliminator: Furnish and install as shown on the drawings coalescing type air eliminators. Pipe size is not a factor and all units shall be selected per the manufacturer's recommendations. All eliminators shall be fabricated steel, rated for 150 psig working pressure the entering velocities not to exceed 4 feet per second at specified GPM. Eliminators specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second. Units shall include an internal bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle must consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate copper medium is to be wound completely around and permanently affixed to each internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Eliminators shall include a bottom connection for use as a blow down connection for periodic cleaning. Air eliminators shall be capable of removing 100% of the free air, 100% of the entrained air and up to 99.6% of the dissolved air in the fluid.

1. Spirovent Senior by Spirotherm, Inc., or approved equal.

EDIT NOTE: Addition of a dirt separator to an air eliminator. See notes for air eliminator above.

J. Air Eliminator and Dirt Separator: Furnish and install as shown on the drawings combination coalescing type air eliminator and dirt separators. Pipe size is not a factor and all units shall be selected per the manufacturer's recommendations. All combination units shall be fabricated steel, rated for 150 psig working pressure with entering velocities not to exceed 4 feet per second at specified GPM. Units specifically designed for high velocity systems may have an entering velocity of up to 10 feet per second. Units shall include an internal bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle shall consist of a copper core tube with continuous wound copper medium permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Air separators shall be capable of removing 100% of the free air, 100% of the entrained air and up to 99.6% of the dissolved air in the system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.

1. Spirovent by Spirotherm, Inc., or approved equal.

K. Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 375 degrees F maximum operating temperature. Provide taps in bottom of tank for tank fitting; taps in end of tank for gauge glass. Tank with taps constructed shall be tested and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1. Furnish with the following fittings and accessories:

1. Air Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless steel ball check (100 gallon unit only); sized for compression tank diameter. Design tank fittings for 125 psig working pressure and 250 degrees F maximum operating temperature.

2. Tank Drain Fitting: Brass body, nonferrous internal parts; 125 psig working pressure and 240 degrees F maximum operating temperature. Fitting shall be designed to admit air to the compression tank and drain water, plus close off the system.

3. Gauge Glass: Full height and have dual manual shutoff valves, 3/4 inch diameter gauge glass, and slotted metal glass guard.

OR

Diaphragm-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 240 degrees F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity, by means of a flexible heavy duty diaphragm securely sealed into tank. Diaphragm shall be permanently sealed for tank sizes up to 45 gallon acceptance volume. For acceptance volumes greater than 45 gallons, tank shall have replaceable diaphragm/bladder. Diaphragm/bladder shall be suitable for glycol service and system water treatment chemicals. Provide taps for pressure gauge and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 1.

L. Pump Suction Diffusers: Cast-iron body, with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger; 175 psig working pressure, 300 degrees F maximum operating temperature; and complete with the following features:

1. Inlet vanes with length 1-1/2 times pump suction diameter or greater.

2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.

3. Disposable fine mesh strainer to fit over cylinder strainer.

4. Permanent magnet, located in flow stream, removable for cleaning.

5. Adjustable foot support, designed to carry weight of suction piping.

6. Blowdown tapping in bottom; gauge tapping in side.

M. Automatic Flow Control Valves: Class 150, cast iron housing, stainless steel operating parts; threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger. Factory set to automatically control flow rates within plus or minus 5 percent design, while compensating for system operating pressure differential. Provide quick disconnect valves for flow measuring equipment. Provide a metal identification tag with chain for each valve, factory marked with the zone identification, valve model number, and rate flow in GPM.

2.3 PIPE ESCUTCHEONS:

A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.4 LOW PRESSURE PIPELINE STRAINERS:

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screen. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inches and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inches and larger steam strainers.

B. Threaded Ends, 2 inch and Smaller: Bronze or Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

F. Grooved Ends, 2-1/2 inches and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

2.5 HIGH PRESSURE PIPELINE STRAINERS:

A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 250 psi working pressure, with Type 304 stainless steel screens. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inch and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inch and larger steam strainers.

B. Threaded Ends, 2 inches and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted steel retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 80 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

2.6 BASKET STRAINERS:

EDIT NOTE: Delete item A except for low (<50 psig) pressure systems.

A. For 50 psig systems or less (thru 12 inches): High-Tensile ASTM A126 Class B cast iron, angle design, ductile iron clamped cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045 inch perforations for through 3 inch diameter piping; .125 inch for 4 inch and larger.

R-P&C 528-C12, Class 125

B. For 125 psig systems or less (thru 12 inch): High-Tensile ASTM A126, Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045" perforations for through 3 inch diameter piping; .125 inch for 4 inch and larger.

R-P&C 528-V12, Class 125

C. For systems operating greater than 125 psig (thru 12 inch): High-Tensile ASTM A126 Class B cast iron, angle design, bolted cover, flanged ends, stainless steel screen assembly, suitable gasket material, bottom threaded drain outlet. Steam screen size shall be .045 inch perforations for through 6 inch diameter piping; .062 inch for 8 inch and larger. Liquid screen size shall be .045 inch perforations for through 3 inch diameter piping; .125 inches for 4 inches and larger.

R-P&C 528-B25, Class 250

2.7 DIELECTRIC WATERWAY:

A. A. General: Zinc electroplated nipple with non-metallic lining for use in service indicated, which effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action and stop corrosion. Union style not acceptable.

2.8 MECHANICAL SLEEVE SEALS:

A. General: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates which cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation, as manufactured by Link-Seal or equal.

B. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

1. Mechanical Sleeve Seals: Installed between sleeve and pipe.

2.9 FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Provide drip pans fabricated from corrosion- resistant sheet metal with watertight joints, and with edges turned up 2-1/2 inches. Reinforce top, either by structural angles or by rolling top over ¼ inch steel rod. Provide hole, gasket, and flange at low point for watertight joint and 1 inch drain line connection.

B. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3 inches and smaller, 20 gauge; 4 inches to 6 inches 16 gauge; over 6 inch, 14 gauge.

2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs. Provide fully welded waterstop/anchor ring fabricated from minimum 1/8 plate, extending minimum 1 inch from O.D. of sleeve, where noted in Part 3.

3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

4. Sleeves for use with firestopping shall be fabricated in accordance with the installation instructions of the firestopping system.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES:

A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.

B. Strainers: Install strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff full port ball valve with ¾ inch hose end and cap in strainer blow down connection. Where indicated, provide drain line from shutoff valve to plumbing drain, full size of blow down connection.

1. Provide strainers in supply line ahead of the following equipment, and elsewhere as indicated.

| Edit the following list and coordinate details on drawings. |
|---|

a. Pumps

b. Pressure reducing valves

c. Temperature or pressure regulating valves

d. Control valves

C. Dielectric Waterways: Dielectric unions between ferrous and non-ferrous piping materials are not acceptable at LPS; dielectric nipples shall be used. Comply with manufacturer's installation instructions.

D. Mechanical Sleeve Seals: Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form watertight seal.

3.2 HYDRONIC SPECIALTIES INSTALLATION:

A. Manual Air Vent: Provide manual air vents at all high points and drops in the direction of flow, of all mains and risers of the hydronic systems, at heat transfer coils, radiation and elsewhere shown and as required for system air venting.

1. Provide enlarged air collection standpipe where large air quantities can accumulate.

2. Use a 1/2 inch ball valve with a soft copper tubing discharge pipe directed to a convenient collection point except as noted below.

3. Use a coin operated air vent inside terminal unit and baseboard radiation enclosures.

B. Provide automatic air vents where shown on drawings. Provide high capacity automatic air vents at all air separators, provide an isolation valve to allow removal of all automatic air vents, provide minimum 1/4 inch soft copper tubing to a convenient drain location, and to avoid water damage.

EDIT NOTE: Delete air outlet piping on systems with diaphragm compression tanks.

C. Air Separator or Air Eliminator: Install inline air separators in hydronic systems pump suction lines. Run air outlet piping to compression tank with 1/4 inch per foot (2 percent) upward slope towards tank. OR Provide high capacity air vent on air outlet. Install drain valve on units 2 inch and larger.

D. Pump Suction Diffuser: Install pump suction diffusers on hydronic systems pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection. Arrange installation to allow strainer removal and replacement.

E. Compression Tank: Install compression tanks in hydronic systems above air separator. Install gauge glass and cocks on end of tank. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

OR

F. Diaphragm-Type Compression Tank: Install diaphragm-type compression tanks in hydronic systems on floor stand as indicated. Provide Schraeder valve on air charge fitting. Vent and purge air from the water side, and charge tank with proper air charge to suit system design requirements.

1. Provide support from the floor or structure adequate to carry twice the weight of the tank, piping connections, fittings, and weight of water assuming a full tank of water. Do not overload building components and structural members.

3.3 INSTALLATION OF FABRICATED PIPING SPECIALTIES:

A. Drip Pans: Locate drip pans under piping as indicated. Hang from structure with rods and building attachments, weld rods to sides of drip pan. Brace to prevent sagging or swaying. Connect 1" drain line to drain connection, and run to nearest plumbing drain or elsewhere as indicated.

B. Pipe Sleeves: In fire resistive construction, coordinate the use of sleeves with the firestopping system requirements. See Section 20 05 18. Do not install sleeves through structural members of work, except as detailed on drawings, or as reviewed by Architect/Engineer. Install sleeves accurately centered on pipe runs. Size sleeves so that piping and insulation will have free movement in sleeve, including allowance for thermal expansion; but not less than 2 pipe sizes larger than piping run. Install length of sleeve equal to thickness of construction penetrated, and finish flush to surface; except floor sleeves where noted below. Provide temporary support of sleeves during placement of concrete and other work around sleeves, and provide temporary closure to prevent concrete and other materials from entering sleeves.

1. Interior gypsum board, plaster, and masonry partitions: Install sheet metal sleeves.

2. Interior cast in place concrete walls: Install steel pipe sleeves.

3. Interior cast in place floors: Install steel pipe sleeves with water stop/anchor ring.

   a. Extend floor sleeves in rooms _____ ½ inch above level floor finish, in rooms _____ ¾ inch above floor finish sloped to drain and 2 inches above finished floor in all mechanical equipment rooms and pipe chases.

4. 4. Below ground and exterior cast-in-place concrete or masonry: Install steel pipe sleeves with waterstop/anchor ring.

5. 5. For core drilled solid concrete or precast concrete with blockouts, no sleeve is required, except provide sheet metal "collar" fastened and caulked to floors required to have extended sleeves.

C. See Section 23 05 48 for acoustical sleeve requirements.

**END OF SECTION 23 21 16**

# SECTION 23 21 23 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of HVAC pumps work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Pumps furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Divisions 20 through 25 sections.

C. Refer to other Divisions 20 through 25 sections for other work; not work of this section.

D. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on pumps. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

2. Interlock wiring between pumps; and between pumps and field-installed control devices.
   a. Interlock wiring specified as factory-installed is work of this section.

E. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and pump control panels.
   a. Control wiring specified as work of Section 23 09 23 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of general-use centrifugal pumps with characteristics, sizes and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI "Hydraulic Institute Standards".

2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 778 "Motor Operated Water Pumps".

3. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

C. Certification, Pump Performance: Provide pumps whose performances, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's pump specifications, installation and start-up instructions and current accurate pump characteristic performance curves with selection points clearly indicated.

B. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to HVAC pumps. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

C. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

D. Maintenance Data: Submit maintenance data and parts lists for each type of pump, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Handle HVAC pumps and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged HVAC pumps or components; replace with new.

B. Store HVAC pumps and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading HVAC pumps, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following unless approved by the **LPS Operations, Maintenance and Construction (OMC) Department**.

1. In-Line Booster Pumps:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco

2. In-Line Circulator Pumps:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco

3. Vertical In-Line Pumps:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco
   c. Allis-Chalmers
   d. Goulds

4. Frame-Mounted End Suction Pumps:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco
   c. Grundfoss
   d. Armstrong

5. Close-Coupled End Suction Pumps:
   a. Bell & Gossett ITT; Fluid Handling Div.
   b. Taco
   c. Grundfoss

d. Armstrong

## 2.2 PUMPS:

A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.

B. Pump motor shall be sized so as not to be overloaded at any point along impeller curve for specified performance.

C. All pump couplers shall be suitable for both constant speed and variable speed operation.

## 2.3 IN-LINE BOOSTER PUMPS:

A. General: Provide in-line booster pumps where indicated, and of capacities as scheduled.

B. Type: Horizontal, oil-lubricated, designed for 125 psi working pressure, 225 degrees F (107 degrees C) continuous water temperature, and specifically designed for quiet operation.

C. Body: Cast iron, split vertical volute, rated for 175 psi, flanged suction and discharge.

D. Impeller: Steel shaft with copper or stainless steel shaft sleeves.

E. Shaft: Steel, ground and polished, integral thrust collar.

F. Bearings: Two horizontal sleeve bearings designed to circulate oil.

G. Seal: Mechanical, with carbon seal face rotating against ceramic seat.

H. Motor: Pump motor shall be non-overloading at any point on pump curve and meet the requirements of Section 23 05 13.

I. Coupling: Self-aligning, flexible coupling.

## 2.4 IN-LINE CIRCULATOR PUMPS:

A. General: Provide bronze fitted in-line circulator pumps where indicated, and of capacities as scheduled.

B. Type: Horizontal mount, vertical split case, oil- lubricated, designed for 175 psi working pressure, and 225 degrees F (107 degrees C) continuous water temperature.

C. Body: Cast iron, with flanged suction and discharge and gauge tappings.

D. Shaft: Hardened alloy steel.

E. Bearings: Oil-lubricated bronze journal bearings.

F. Seal: Mechanical, with carbon seal ring and ceramic seat.

G. Motor: Pump motor shall be non-overloading at any point on pump curve and meet requirements of Section 23 05 13.

H. Coupling: Self-aligning, flexible coupling.

I. Impeller: Brass or Bronze enclosed type, hydraulically and dynamically balanced, and keyed to shaft.

## 2.5 VERTICAL IN-LINE PUMPS:

A. General: Provide bronze fitted vertical in-line pumps where indicated, and of capacities as scheduled.

B. Type: Vertical mount, in-line, close-coupled, single stage, designed for 175 psi working pressure.

C. Body: Cast iron, 125/250 psi ANSI flanges of equal size, tappings for gauge and drain fittings.

D. Shaft: Steel with replaceable shaft sleeve.

E. Seal: Mechanical seal with ceramic seal seat.

F. Motor: Pump motor shall be non-overloading at any point on pump curve, open and meet requirements of Section 23 05 13.

G. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw. Assembly components shall be 304 stainless steel.

## 2.6 FRAME-MOUNTED END SUCTION PUMPS:

A. General: Provide frame-mounted bronze fitted end suction pumps where indicated, and of capacities and having characteristics as scheduled.

B. Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 psi working pressure.

C. Casing: Cast iron, 125 psi ANSI flanges, tappings for gauge and drain connections.

D. Shaft: Steel with replaceable shaft sleeve.

Use sleeve bearings where quiet operation is essential.

E. Bearings: Re-greaseable ball [sleeve] bearings.

Condenser Water: Use ceramic type seal with rotating carbon - not tungsten carbide.

F. Seal: Mechanical, with carbon seal ring and ceramic seat.

G. Motor: Pump motor shall be non-overloading at any point on pump curve and meet requirements of Section 15040.

H. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw. Assembly components shall be 304 stainless steel.

I. Baseplate: Structural steel with welded cross members, and open grouting area.

J. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.

## 2.7 CLOSE-COUPLED END SUCTION PUMPS:

A. General: Provide bronze fitted close-coupled end suction pumps where indicated, and of capacities and having characteristics as scheduled.

B. Type: Horizontal mount, single stage, vertical split case, designed for 175 psi working pressure.

C. Casing: Cast iron, 125 psi ANSI flanges, tappings for gauge and drain connections.

Use sleeve bearings where quiet operation is essential.

D. Bearings: Re-greaseable ball [sleeve] bearings.

E. Shaft: Steel with replaceable shaft sleeve.

Condenser Water: Use ceramic-type seal with a rotating carbon - not tungsten carbide.

F. Seal: Mechanical, with carbon seal ring and ceramic seat.

G. Motor: Pump motor shall be non-overloading at any point on pump curve, open and meet requirements of Section 23 05 13.

H. Impeller: Bronze enclosed type, hydraulically and dynamically balanced, keyed to shaft and secured with locking screw. Assembly components shall be 304 stainless steel.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which HVAC pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PUMPS:

A. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized industry practices to ensure that HVAC pumps comply with requirements and serve intended purposes.

B. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.

C. Support: Install base-mounted pumps [with inertia base] on minimum of 4" high concrete base equal or greater than 3 times total weight of pump and motor, with anchor bolts poured in place. Set and level pump, grout pump base with non-shrink grout.

1. Install in-line pumps, supported from piping system.

D. Support: Refer to Section 23 05 48 "Vibration Control" for support and mounting requirements of HVAC pumps.

1. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Contractor.

E. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

Provide cyclone separator or filtering device ahead of condenser water pumps to filter out solids.

F. Piping Connections: Refer to Section 23 20 00 and other Division 20 and 22 piping sections. Provide system return connection to inlet strainer with valved bypass to drain. Provide pump discharge connections with check valve, shutoff valve, and balancing valve for each pump.

3.3 ADJUSTING AND CLEANING:

A. Alignment: Adjust shafts of all motors and pumps within recommended tolerances by the manufacturer, and in presence of manufacturer's service representative.

B. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

C. Refer also to Section 23 05 93 for pump system balancing; not work of this section.

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

**END OF SECTION 23 21 23**

# SECTION 23 23 00 - GLYCOL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of glycol system required by this section is indicated on drawings and/or specified in other Divisions 20 through 25 sections.

B. Types of glycol system specialties specified in this section include the following:

1. Fill tank
2. Pressure sensor
3. Pressure relief valve
4. Check valve
5. Propylene glycol
6. Feed Pump
7. Transfer Pump

C. Glycol systems specialties furnished as part of factory-fabricated equipment shall meet or exceed requirements of this section.

D. Refer to other Divisions 20 through 25 sections for mechanical insulation valves, meters and gauges and basic piping materials and methods.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of glycol systems of types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Glycol System Types: Provide glycol system specialties of same type by same manufacturer.

C. Codes and Standards: Provide glycol system components and materials to meet all local and national codes and standards.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions and dimensioned drawings for each type of manufactured equipment and material. Include pressure drop information. Submit schedule showing manufacturer's model or figure number, size, location and features for all equipment and material.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured equipment. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

C. Submit glycol solution strength test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. District Water Treatment Contractor is “Rocky Mountain Aquatech”. All Water Treatment work to be performed by Rocky Mountain Aquatech.

B. Manufacturer: Subject to compliance with requirements, provide one of the following products furnished by "Rocky Mountain Aquatech".

1. Glycol System Tank:
   a. Wetcorp
   b. Sage Industries
   c. Nalco
   d. Mogul
   e. Chem Aqua
   f. H.O.H.

2. Inhibited Propylene Glycol Solution:
   a. Dow Chemical Dowfrost
   b. Interstate Chemical Intercool NFP.

2.2 REFER TO SECTIONS 23 20 00 AND 23 21 16 FOR TYPE OF PIPE AND FITTINGS TO BE USED.

2.3 GLYCOL SYSTEM:

A. Tank: Provide Glycol Feed System consisting of a 35 [ ] gallon polyethylene tank with a removable polyethylene cover. A ½ inch suction and under drain with hose bib for draining the tank and a pump shut off valve shall be provided. The tank shall be supported by 4 legs with foot pads as an integral part of the tank.

| Edit Note: Coordinate alarm points with Temperature Control Specification. Coordinate power requirements with Electrical Engineer. |
|---|

B. Controls: The control cabinet shall be a NEMA I enclosure with a large LEXAN viewing window mounted in the cabinet door. The following components shall be mounted on the inside panel: Low level liquid alarm light, low level alarm silencer switch, pump test switch and indicating light, and a 0-60 psi system pressure gauge. The low level switch shall be mounted 3inches above the bottom of the tank. A low level audible alarm shall be mounted in the side of the panel. In addition, two extra, normally open contacts shall be provided for remote low level warning light or alarm. A 3-35 psi adjustable pressure switch shall control the system pressure.

C. Pump: The pump shall be an Oberdorfer, all bronze, rotary gear pump with a 1/3 hp-1725 rpm motor mounted integrally with the pump. The pump shall be designed to produce 1.8 gpm at 40 psi. Electrical characteristics: 120V./60Hz/1 phase/1/3 HP.

D. Piping: Type L copper pump discharge, including a 3/4inch check valve, 3/4inch threaded female "T" for connecting the Glycol Feeder to the system piping, and a Watts pressure relief valve set at 50 psi, which will dump any system over pressure back to the glycol feed tank.

E. Transfer Pump: Hand operated rotary type, 8feet-0inches long 1inch hose with 3/4inch non-sparkling nozzle, 1inch telescoping suction pipe, adaptor with 2inch thread.

2.4 GLYCOL SOLUTION:

A. Provide [50percent] 40percent [30percent] glycol solution for [burst] freeze protection to a temperature of [ ].

B. Provide on extra 45 gallon drum of propylene glycol.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Refer to drawing and provide necessary piping to complete installation.

B. Thoroughly clean and flush system before adding propylene glycol solution.

C. Feed pre-mixed propylene glycol solution to system. Water used for dilution shall have a total hardness of less than 50 ppm, and a total chloride and sulfate of less than 25 ppm. Contractor shall assume that building potable water is/is not suitable, unless tested to prove otherwise.

D. Perform tests determining strength of propylene glycol solution before system is turned over to the Owner. Provide test prior to end of the first year of operation and replenish as required.

E. Set up glycol feeder control for proper operation. Set pressure switch to feed glycol to system at 12 psi.

F. At time of Completion, glycol feeder shall be filled with a full tank of the proper solution.

**END OF SECTION 23 23 00**

# SECTION 23 23 16 – REFRIGERANT PIPING SPECIALTIES

PART 1 - GENERAL:

1.1 WORK INCLUDED:

| Indicate all work to be covered by this section. Edit portions of work indicated to suit job requirements. |
|---|

A. Liquid indicators.
B. Strainers.
C. Refrigerant driers.
D. Filter-driers.
E. Solenoid valves.
F. Expansion valves.
G. Refrigerant charging valves.
H. Flexible connections.

1.2 REQUIREMENTS OF REGULATORY AGENCIES:

A. Comply with applicable regulations and mechanical refrigeration codes.

1.3 SUBMITTALS:

A. Submit shop drawings and product data in accordance with Section 15010. [ .]
B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Liquid Indicators
   1. ITT Fluid Handling Division
   2. Fisher and Porter
   3. Miriam Instrument Co.

B. Strainers
   1. Automatic Switch Co.
   2. Mueller Brass Co.

C. Refrigerant Dryers
   1. AMF Cuno Div.
   2. Mueller Brass Co.

D. Filter Dryers
   1. AMF Cuno Div.
   2. Mueller Brass Co.

E. Solenoid Valves
   1. Automatic Switch Co.
   2. Barber-Colman Co.
   3. Honeywell Co.

F. Expansion Valves
   1. Sporlan Valve Co.
   2. The Singer Co.

G. Charging Valves

H. Flexible Connectors
1. Aeroquip Corp.
2. Flexonic Div.
3. Thermotech Corp.

I. Substitutions: Items of same function and performance are acceptable in conformance with Section 23 05 00. [_____.]

2.2 LIQUID INDICATORS:

A. Double-port type with copper or brass body and flared or solder ends.
B. Provide removable seal caps on each port for inspection of refrigerant condition.
C. Provide full size liquid indicators in main liquid line leaving condenser. If receiver is used, install in liquid line leaving receiver.

2.3 STRAINERS:

A. Angle type with brass shell and replaceable cartridge.
B. Suitable for refrigerant and piping material utilized in the system.
C. Provide full size strainer ahead of each automatic valve. Where multiple expansion valves with integral strainers are used, install single main liquid line strainer.
D. On steel piping systems provide strainer in suction line to remove scale and rust.
E. Provide shut-off valve on each side of strainer to facilitate maintenance.

2.4 REFRIGERANT DRIERS:

A. In-line or angle type with copper or brass shell.
B. Provide replaceable desiccant drier material.
C. Provide full flow permanent refrigerant drier in low temperature systems and systems utilizing hermetic compressors.
D. Provide three-valve by pass assembly.

2.5 FILTER-DRIERS:

A. Angle type, with brass shell and using combined straining and drying material.
B. Employ replaceable desiccant material.
C. Acceptable in lieu of separate strainers and driers.
D. Provide three-valve by pass assembly.

2.6 SOLENOID VALVES:

A. Copper or brass body with flared or threaded ends.
B. Use replaceable coil assembly.
C. Provide a manually operated stem to permit operation in case of coil failure.

D. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

2.7 EXPANSION VALVES:

A. Angle type or straight through design suitable for the refrigerant utilized in the system.

B. Brass body, internal or external equalizer, and adjustable superheat setting, complete with capillary tube and remote sensing bulb.

C. Size expansion valves to avoid being undersized at full load and excessively oversized at partial load.

D. Evaluate refrigerant pressure drop through system to determine the available pressure drop across each valve.

E. Select valves for maximum load at design operating pressure and minimum 43 degrees F (6 degrees C) of superheat.

2.8 CHARGING VALVES:

A. General purpose type with brass body, flared or solder ends and removable valve core.

B. Provide valve inlet with quick coupling connection for ease of charging.

C. Provide refrigerant charging connections in liquid line between receiver shut-off valve and expansion valve.

2.9 FLEXIBLE CONNECTORS:

A. Close pitch corrugated bronze hose with single layer of exterior braiding.

B. At least 9 inches (229 mm) long with bronze fittings.

C. Utilize only at or near compressors where it is not physically possible to absorb vibration within piping configuration.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install refrigeration specialties in accordance with manufacturer's instructions.

3.2 REFRIGERANT DRIERS:

A. Mount drier vertically in liquid line adjacent to receiver with bypass assembly to permit isolation of drier for servicing.

3.3 FILTER DRIERS:

A. Install with bypass assembly to permit isolation for servicing.

3.4 EXPANSION VALVES:

A. Locate expansion valve sensing bulb immediately after evaporator outlet on suction line.

**END OF SECTION 23 23 16**

# SECTION 23 25 00 - WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of water treatment system work required by this section is indicated on drawings and schedules and by requirements of this section, and includes necessary equipment, chemicals, and service for the following systems:

1. Condenser Water Systems
2. Closed Hot Water Systems
3. Closed Chilled Water Systems
4. Steam Boiler Systems
5. Water Conditioners
6. Cleaning of Piping Systems
7. Sterilization of Domestic Water System

B. Provide chemicals and service program for a period of one year from start-up date of equipment, including the following:

1. Initial water analysis and recommendations.
2. Systems start-up assistance.
3. Training of operating personnel.
4. Periodic field service and consultation.
5. Customer report charts and log sheets.
6. Laboratory technical assistance.

1.2 QUALITY ASSURANCE:

A. Manufacturer's and Representative Qualifications. Firms regularly engaged in manufacture of water treatment equipment, chemical and service shall have been active in the field of industrial water treatment and whose products have been in satisfactory use in similar service for not less than 5 years, and shall have full-time service personnel located within the trading area of job site.

B. Codes and Standards:

1. ASME Compliance: Construct softener tanks in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, provide stamp and certification.

2. UL Labels: Provide water conditioners ancillary electrical components, which have been listed and labeled by UL.

3. NEMA Standards: Provide electrical controls and enclosures conforming to applicable standards of NEMA for environment where water conditioners are indicated.

4. NSE Compliance: Construct and install water conditioners in accordance with NSF Standard 44 "Cation Exchange Water Softeners Relating to Supplementary Treatment of Potable Water."

5. Chemical Standards: Provide only chemical products, which are acceptable under state and local public health and pollution control regulations.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product including rated capacities of selected equipment clearly indicating water pressure drops, weights, installation and start-up instructions, and furnished specialties and accessories.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to water treatment equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts list for each item of equipment, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Handle water treatment materials and components carefully to prevent damage, breaking, denting and scoring to materials and equipment. Deliver packaged units in original crates. Do not install damaged water treatment materials and components; remove from site and replace with new.

B. Store water treatment materials and components in an environment satisfactory to prevent their damage by the elements.

1.5 EXTENDED MAINTENANCE SERVICES:

A. Agreement to Maintain: Prior to time of final acceptance, submit four copies of "Agreement for continued Service and Maintenance" for water treatment system, for Owner's possible acceptance. Offer terms and conditions for furnishing chemicals and providing continued testing and servicing, and including replacement of materials and equipment, for one-year period with option for renewal of Agreement by Owner.

PART 2 - PRODUCTS

2.1 SUPPLIERS:

A. Suppliers: Subject to compliance with requirements, provide products by one of the following:

1. Water Treatment System:
   a. Aqua Tech
   b. Summitt Labs
   c. Mogul Div.
   d. International Chemtex

2. Water Conditioners and Filtering Equipment
   a. Columbia Water Conditioning Co.
   b. Permuitt
   c. Culligan
   d. US Filter

3. Filter Feeder:
   a. Neptune

4. Sand Filter
   a. Bruner
   b. Pep

5. Solid Separator
   a. Griswold
   b. Lakos

2.2 OPEN TYPE SYSTEMS:

A. Provide an open system chemical feed and control system sized and equipped to chemically treat the raw makeup water available at the project site.

B. Except as otherwise indicated, provide an open water treatment system of manufacturer's standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.

C. TOWER CONTROLLER:

1. Provide a pre-fabricated, pre-wired and pre-piped automatic tower control system to feed inhibitor and bleed solids in direct proportion to the bleed and/or evaporation of the cooling tower water system. The automatic control of biocide used to eliminate bio-fouling shall be a part of this controller.

2. The controller shall be enclosed in a NEMA 1-R, rain-tight enclosure with brackets for mounting and shall have pad-locking hasp. The control door shall be hinged, and contain a large Lexan viewing window. Overriding and operating switches with indicating lamps, for the following functions, shall be mounted on the inside panel: Power, Flow, Inhibitor Pump Operation, Biocide Pump Operation, and Bleed Operation.

3. The TDS control shall be of the solid state design. A fuse and fuse holder, 6inch linear reading TDS meter (0 to 5000 Micro Mho) and its controls shall be mounted on the inside panel of the controller. Inhibitor feed and bleed will be controlled by the TDS, set into the controller, by the operator. The TDS meter will allow the operator to continuously read the system TDS. The control point setting for the TDS will be independent from the monitoring feature of the controller, which will allow the operator to compare the system TDS to the control point setting, without disturbing the TDS control point setting. Both Chemical Feed and bleed are controlled with this equipment at the same time.

4. An automatic biocide control shall be mounted on the inside panel of the controller. This control shall be capable of controlling the feeding of biocide automatically on a 1-7 day schedule. The biocide control shall incorporate a 0-90 minute solid state timer with a dial on the face of the biocide control panel to control the time the biocide pump will operate. During the Biocide Cycle, the controller will automatically disconnect the TDS control from the system so as to permit the retention of the biocide in the tower water.

5. A pump rack shall be attached to the bottom of the tower controller and contain the following equipment: 1inch inline flow and bleed assembly, consisting of a pressure switch, used for flow control, TDS sensor with a removable probe, check valve, two chemical injection points and a bleed system, consisting of a flow control valve, and an electric bleed valve, sized to meet the requirements of the tower bleed.

6. Pumps shall be capable of adjusting their stroke during operation and be diaphragm operated. Pumps shall be designed for the purpose, head pressure and volume for which they are to operate which shall be the responsibility of the Water Treatment Contractor. All pumps shall have a flame retardant plastic housing and wetted components and shall be chemical resistant to the materials being pumped. The pumping head shall incorporate a pressure relief valve so that the chemical can be diverted back to the supply in the event of an overpressure. Pumps shall operate on 115v/60HZ.

OR

D. TOWER CONTROLLER:

1. Provide a pre-fabricated, pre-wired, and pre-piped automatic tower control system to feed inhibitor and bleed solids in direct proportion to the makeup of the cooling tower water system. The automatic control of biocide used to eliminate bio-fouling shall be a part of this controller.

2. The controller shall be enclosed in a NEMA 1-R, rain-tight enclosure with brackets for mounting and shall have padlocking hasp. The controller door shall be hinged, and contain a large Lexan viewing window. Overriding and operating switches with indicating lamps, for the following functions, shall be mounted on the inside panel: Power, Flow, Inhibitor Pump operation, Biocide Pump operation, and Bleed operation.

3. The TDS and Pulse control shall be of the solid state design. A fuse and fuse holder, 6inch linear reading TDS meter (0 to 5000 Micro Mho) and its controls shall be mounted on the inside panel of the controller. Bleed shall be controlled by the TDS set into the controller by the operator. The TDS meter will allow the operator to continuously read the system TDS. The control point setting for the TDS will be independent from the monitoring feature of the controller, which will allow the operator to compare the system TDS to the control point wetting without disturbing the TDS control point setting. The PULSE CONTROL is a 0 - 90 second solid state timer with a dial on the face of the TDS controller. When the pulse timer receives a pulse from the tower makeup water meter, it will operate the inhibitor pump for the time set into it by the operator.

4. The water meter shall be a contact-output type water meter, designed to deliver an electronic signal when a specific volume of water passes through the meter, and shall be installed in the water makeup line to the cooling tower. Meter shall be a ___inch meter, with a magnetic drive hermetically sealed register, and shall meet the AWWA Standard for water meters. Gallons per pulse shall be responsibility of the Water Treatment Contractor.

5. An automatic biocide control shall be mounted on the inside panel of the controller. This control shall be capable of controlling the feeding of biocide automatically on a 1-7 day schedule. The biocide control shall incorporate a 0 - 90 minute solid state timer with a dial on the face of the biocide control panel to control the time the biocide pump will operate. During the Biocide Cycle, the controller will automatically disconnect the TDS control from the system so as to permit the retention of the biocide in the tower water.

6. A pump rack shall be attached to the bottom of the tower controller and contain the following equipment: 1inch inline flow and bleed assembly, consisting of a pressure switch, used for flow control, TDS sensor with a removable probe, check valve, two chemical injection points and a bleed system, consisting of a flow control valve, and an electric bleed valve, sized to meet the requirements of the tower bleed.

7. Pumps shall be capable of adjusting their stroke during operation and be diaphragm operated. Pumps shall be designed for the purpose, head pressure and volume for which they are to operate which shall be the responsibility of the Water Treatment Contractor. All pumps shall have a flame retardant plastic housing and wetted components and shall be chemical resistant to the materials being pumped. The pumping head shall incorporate a pressure relief valve so that the chemical can be diverted back to the supply in the event of an overpressure. Pumps shall operate on 115v/60HZ.

OR

E. TOWER CONTROLLER:

1. Provide a pre-fabricated tower control system designed to feed inhibitor and solids in direct proportion to the bleed and/or evaporation of the cooling tower water system for use on outdoor towers. The TDS control shall be of solid state design, enclosed in a NEMA 12-X enclosure complete with hinged Lexan door, pad locking hasp, eight-foot power cord with molded plug and a duplex receptacle for bleed valve.

2. Electrode shall be temperature-compensated, 3/4inch NPT screw type, with eight-foot electrode cord and quick electric disconnect connector.

3. Biocide feed attachment shall be supplied by the water treatment contractor and installed by the mechanical contractor for attachment to the side of the cooling tower, so that a liquid biocide can be added on a regular basis to the tower from the outside of the tower.

4. Provide a 1/2inch weatherproof 115v/60 HZ solenoid valve and a 1/2inch flow control valve for the tower bleed.

5. A crystal dry type chemical feeder shall be provided by the water treatment contractor for installation by the mechanical contractor, in the makeup water line to the cooling tower. The feeder shall be designed and sized to supply chemical to the tower as it is called for.

6. Protection of the chemical feeder from freezing shall be provided for by the mechanical contractor if required.

F. EVAPORATIVE SECTION CONTROLLER:

1. Provide a pre-fabricated air washer chemical feed and control system, to bleed solids and feed chemicals in direct proportion to the evaporation and bleed of the evaporative coolers.

2. All of the electronic control equipment shall be mounted in a NEMA raintight enclosure. The controller shall incorporate side brackets for mounting and shall incorporate a Lexan window mounted in the cabinet door and shall have pad locking hasp.

3. The TDS control shall be of the solid-state design with a submersible sensor for measuring TDS. A fuse, fuse holder, an 6inch linear reading meter (2 scale, 0 - 5000 Micro Mho) and its controls shall be mounted in the controller and will allow the operator to continuously read the system TDS. The control point setting for the TDS will be independent from the monitoring feature of the controller, which will allow the operator to compare the system TDS to the control point TDS setting without disturbing the control point setting.

4. Provide a 1/2inch weatherproof solenoid valve and 1/2inch flow control valve for field installation.

5. A crystal dry type chemical feeder shall be provided by the water treatment contractor for installation by the mechanical contractor, the water makeup water line to the air washer. The feeder shall be designed and sized to supply chemical to the tower as it is called for.

6. Electrical requirements for the control system shall be 115v/60 HZ/3 amp.

G. CORPORATION STOP:

1. Provide a 3/4inch NPT CPVC Corporation stop for injection of chemicals into the main stream condenser water piping.

H. SOLIDS SEPARATOR:

1. Provide and install, as shown on the drawings, a [ ] inch diameter automatic solids separator to remove suspended matter from the recirculating tower water by centrifugal action.

2. The separator shall be capable of removing 98percent of the suspended particles larger than 45 microns with a specific gravity no greater than 2.6 from [ ] gpm of the water passing through it. Pressure drop through the separator shall be no higher than 9 psig.

3. A 3/4inch motorized weatherproof ball valve 120/60HZ/1 amp., with a programmable solid state timing control, shall be provided to automatically purge collected solids from the bottom of the separator. The timer control cycle shall be adjustable between 1 - 24 hours and the length of time that the valve shall be open will be adjustable between 5 - 90 seconds.

I. SAND FILTER:

1. Provide an automatic sand filter for removing contaminates from the cooling tower water. The filter shall consist of a 304 stainless steel filter tank complete with pressure gauge and automatic air vent. Backwash shall be automatic, utilizing source water for backwash and will be initiated by pressure differential. The control valve shall be a multiport directional control valve with backwash timer and pressure differential switch.

2. Media shall remove 90percent by volume of the suspended solids, 10 microns and larger.

3. The Control Box shall be NEMA 3R with thermal overload protection. A stepdown transformer will be supplied to convert power to 110 volt [ ] for controls, and motor starter. The complete unit shall be skid mounted on a steel channel skid.

## 2.3 CLOSED SYSTEMS:

A. Provide a closed system chemical feed and control system sized and equipped to treat the raw makeup water available at the project site.

B. Except as otherwise indicated, provide closed water treatment system of manufacturer's standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.

C. FILTER FEEDER:

1. Provide, as shown on the drawings, a Filter Feeder and install it in a by-pass loop around the circulating pump of each closed system for the purpose of introducing special chemicals and cleaning the system water. The Filter Feeder shall consist of a steel tank designed for operation 250 degree water at 100 psi. A 3-1/2inch quick opening cap with "0" ring seat shall be provided on the top of the filter to add chemical and filter media. 1-1/2inch cubic feet of filter media, consisting of crushed rock, pea gravel, sand and anthracite shall be installed in the filter as directed by the manufacturer. The back wash flow rate for the filter shall be no more than 4 gpm. All interconnecting face piping shall be 3/4inch, pre-piped and supplied with the filter feeder.

D. CLOTH BAG FILTER:

1. Provide a 5 Gallon Chemical Pot Feeder with a special Bag Filter Adapter and five replacement bag filters. The pot feeder shall be installed in a by-pass loop around the circulating pump of each closed system, as shown on the drawings, for the purpose of introducing special chemicals and cleaning of the system water. A 3-1/2inch quick opening cap with "0" ring seat shall be provided on the top of the pot feeder to add chemical and for changing the filter bag.

E. BY-PASS FEEDER:

1. Provide a By-Pass Feeder for adding chemical to the closed water system. The Feeder shall have two 3/4inch NPT female pipe connections, and a 3-1/2inch quick top opening cap, with "0" ring seat. Capacity of the Feeder shall be [___] gallons, capable of operating at 250 psig and at a temperature up to 212 degrees F. The By-Pass feeder shall be mounted no higher from the floor than 48 inches.

F. GLYCOL FEEDER:

1. Provide Glycol Feed System consisting of a 50 gallon polyethylene tank with a removable polyethylene tank cover. A 1/2inch suction and underdrain system, with hose bib, for draining the tank, and a pump shut off valve. The tank shall be supported by four steel legs with foot pads and the pump mounted under, for positive suction, as an integral part of the tank.

2. The control cabinet shall be a NEMA 1 enclosure with Lexan viewing window mounted in the cabinet door. The following components shall be mounted on the inside panel: Low liquid level alarm light, low liquid level alarm silencer switch, pump test switch and, pump operating, indicating light. A 0 - 60 psi system pressure gauge. An adjustable drum low level sensor shall prevent the positive displacement pump from operating when the tank liquid level is low and shall also audibly sound an alarm when tank level is low. In addition, two extra normally open dry contacts shall be provided for remote low tank level warming alarm. A 3 - 35 psi adjustable pressure switch shall control system pressure.

3. The pump shall be an Oberdorfer or approved equivalent, all bronze, rotary gear pump with a 1/2 HP 1725 rpm motor mounted integrally with the pump. The pump shall be designed to produce 1.8 gpm at 40 psig. Electrical characteristic: 120 v/60 HZ/1phase/1/3 HP.

4. The glycol Feeder discharge shall consist of a 3/4inch check valve, 3/4inch threaded female "T", for connecting the Glycol Feeder to the system piping, and a Watts pressure relief valve set at 50 psig, which will dump any closed system over pressure, back into the Glycol Mixing Tank.

G. GLYCOL TRANSFER PUMP:

1. Provide a Hand-Operated Rotary Transfer Pump with 8 feet of 1 inch hose and a non-sparking 3/4inch nozzle for the transferring of glycol from the glycol container to the glycol feed tank. The pump shall have a 1 inch telescoping suction pipe, and bung adapter with 2 inch thread.

## 2.4 STEAM BOILERS:

A. Provide system sized and equipped to treat raw water available at project site and to maintain the following characteristics of water in the steam boiler (tested values for boiler operation):

1. Hardness:0.0
2. Iron:0.0
3. Silica: 60 ppm or less.
4. Total Dissolved solids (TDS): 1500-1700 ppm
5. pH: 10.5 or above.

B. Except as otherwise indicated, provide steam boiler water treatment system of manufacturer's standard materials and components as indicated by published product information, and as recommended by manufacturer for application indicated.

C. WATER SOFTENER:

1. Provide water softener for the steam boiler feedwater system, based on feedwater makeup requirements of the steam boiler.

D. SHOT FEEDER/POT FEEDER:

1. Shot Feeder: Provide one, 2 Gal. One Shot Pot Feeder for each system, boiler. The one shot feeder shall be installed on the by-pass line of the steam boiler feed water line, no higher than 48inches above the floor, for the purpose of introducing special chemicals to the steam boiler as they are needed. The one shot feeder shall be 2-gal. capacity, constructed of 11 gauge steel with 3/4inch diam. with a quick opening cap and "0" ring seals rated for 200 psi and temperatures of 212 degrees F.

E. STEAM BOILER CHEMICAL FEED CONTROL SYSTEM:

1. Provide the following type of Steam Boiler Chemical Feedwater control system:

a. Deaerator Chemical Feed: Provide one Simplex pump package consisting of a diaphragm type pump with internal relief valve. The pump shall be mounted on a 55 [ ] gallon polyethylene tank with steel legs. An agitator with a stainless steel shaft shall be mounted on the tank. The pump shall be capable of pumping against 75 psi at a flow rate of 6 gallons per day. Both the pump and agitator will operate with 115 volts, 60 cycles.

b. Water Meter: Provide a [ "] cast bronze electric contacting water meter. Water meter shall be installed in the cold water make-up line to the Deaerator feed water tank. The water meter shall send electric impulses to the automatic pump controller. Meter shall be totalizing-type, 5 digit times a constant, with a sweep pointer.

c. Pump Controller: The pump controller shall store counts from the electric contacting water meter. When the prescribed number of gallons of feed water has been used, the controller will operate the chemical feed pump, feeding the chemical to the deaerator for a preset prescribed time. The pump timer shall have a 0 to 9 minute timer.

2. Provide the following type of Steam Boiler Chemical Feed System:

a. Pump Package: The chemical feed tank shall be a 55 gallon polyethylene tank, with hinged lid, steel tank support frame with legs and agitator bracket. The pump shall be mounted under the tank for positive suction.

The pump shall be a duplex diaphragm positive displacement type with micrometer dial, adjustable while the pump is running through 100percent of its range. It shall have a cast iron body and the pump shall be capable of pumping 3 gph at 400 psi and operating at [115v/60hz] [ ]. The motor housing shall be TENV with thermal overload.

Chemical for each boiler shall be fed directly into the boiler steam drum.

b. Boiler Chemical Controller: Provide prefabricated boiler chemical feed system to add boiler chemicals to one or more steam boilers, based on the boiler feed water requirements of each boiler.

The controller shall be self-contained in a NEMA rain-tight, wall mounted, enclosure, incorporate side brackets for mounting and shall have a padlocking hasp. The controller door shall be hinged, and contain a large Lexan viewing window. Overriding and operating switches with indicating lamps, for the following functions, shall be mounted on the inside control panel: On and Off power switch with light. Indicating lights and switches for manual operating of chemical feed pump for Boiler No. 1 and Boiler No. 2 chemical feed. Automatic and manual operation switch for agitator. Control for the above controller shall be a dry auxiliary contact on each of the boiler water level controllers. Power will be 116v/60Hz/10 amp.

c. Agitator: The agitator shall be clamp mounted with a stainless steel shaft and prop. Power will be 115v/60 Hz.

d. Valves: Two 1/4inch NPT high temperature Asco solenoid valves shall be supplied as shown on the drawing. Power 115v/60 Hz.

F. BOILER CHEMICAL FEED SYSTEM PUMP PACKAGE:

1. Provide the following type of Steam Boiler Chemical Feed System:
   a. CHEMICAL FEED PUMP PACKAGE: The chemical feed tank shall be a 55 gallon polyethylene tank, with hinged lid. A steel frame tank support, with legs and agitator bracket, shall be supplied. A slide mount pump rack for each boiler chemical feed pump shall be supplied. A side mount pump rack for each boiler chemical feed pump shall be mounted adjacent to the tank stand with the pumps mounted on the rack. The tank shall incorporate a drain valve with a suction valve for each pump.
   b. AGITATOR: A 1/4 HP, 115 VAC agitator with a stainless steel shaft and propeller shall be mounted on the chemical tank agitator support bracket and shall be controlled by the chemical feed controller.
   c. PUMP: Provide two [ ] simplex positive displacement metering pumps. (115 VAC with 230 feet of head pressure at 1 gph. Pump motor housings shall be TENV with thermal overload protection. The pump drives shall be totally enclosed with no exposed moving parts and shall have a micrometer dial for adjusting the pumping capacity throughout its full pumping range with an internal pressure relief valve built into each pump. Materials of

construction for wetted ends shall be stainless steel with stainless steel check balls. The pump discharges shall be 1/4inch NPT to allow for easy assembly to the boiler. The pumps shall be controlled by the Boiler Chemical Controller. A suction valve and strainer shall be provided with each pump.

d. CONTROLLER: The controller shall be self-contained in a NEMA 4 wall mounted enclosure. Overriding and operating switches with indicating lamps, for the following functions, shall be mounted on the face of the controller.
   1) Power switch and indicating light.
   2) Agitator switch: HAND-OFF-AUTOMATIC with indicating light.
   3) Boiler operating switches: HAND-OFF-AUTOMATIC with indicating lights.
   4) Three pump timer controls (0 to 6 minutes)

   The controller shall provide a 6 foot power cord and receptacle on the bottom of the controller for the agitator and boiler chemical feed pump. Power for the controller, shall be 115 VAC/60 HZ 10 AMP.

   Control for the chemical controller shall be an auxiliary dry contact switch mounted on the boiler feedwater pumps, so that when a coiler calls for feed water, it will also start the boiler chemical feed pumps and open the valve for that boiler's chemical feed pump high temp solenoid valve.

e. Deaerator Chemical Feed Package: One 55 gallon polyethylene tank with hinged lid, agitator and pump mounted on lid with polyethylene floating cover, on inside.
   1) One 55 gallon polyethylene tank, with hinged lid and polyethylene floating cover.
   2) One agitator, with mounting bracket. 115 VAC.
   3) One positive displacement electronic metering pump (115 v. 60 Hz) with 230 feet head pressure @ 15 gpd. Pump to include suction and discharge valves, with foot valve and injection valve. Materials of construction for wetted end shall be PVC, with ceramic balls. Output volume of the pump shall be adjustable while pump is in operation from zero to maximum capacity. Pump shall be designed for the purpose, head pressure and volume for which is to operate, and be the responsibility of the water treatment contractor.

   Volume adjustment shall be readily accessible dial knobs. One for changing stroke length and the other for changing stroke frequency. The pump drive shall be totally enclosed with no exposed moving parts. A solid state electronic pulser shall be fully encapsulated with no exposed printed circuits. Electronics shall be housed in a chemical resistant enclosure. Pump shall automatically stop pulsating when the discharge pressure exceeds pump pressure rating by not more than 35percent.

   Chemical pump valves, shall be ball type, with ceramic balls seating on a combination valve seat and seal ring. Pump head, fittings and connections at the pump head shall be PVC. A foot valve with integral one peace strainer shall be provided for the suction line, and an injection check/back pressure valve with 1/2inch NPT male connection for the injection point shall be provided.

f. Pulse Timer: One pulse timer, designed to accept a signal from a water meter, and operate the deaerator chemical feed pump for a period of 0 to 10 minutes. The pumps feeder shall be housed in a 9" x 5-1/5" NEMA-1 high impact resistant gray, glass-filled polycarbonate cabinet, for wall mounting behind the deaerator chemical package. The package shall have a light on the face of the controller, which will indicate when power is applied to the deaerator chemical package.

The package shall have a light on the face of the controller, which will indicate when power is applied to the deaerator chemical feed pump. To check operation, a momentary push button switch shall be mounted on the face of the controller, to substitute for the switch closure of the water meter, or auxiliary contact. The controller shall include a six foot power cord with a molded plug, for inserting into a 120 VAC wall socket. the controller shall be capable of switching 156 amp. at 125 VAC (resistive load). Power consumption is 7VA at 120VAC.

G. BOILER SKIMMER BLOWDOWN SYSTEM:

1. Each steam boiler shall be supplied with a skimmer blowdown control, consisting of:
   a. One - Steam Boiler Automatic Timed Sample Method Skimmer Blowdown Controller, mounted in a NEMA Type 1 enclosure with Lexan viewing window and padlocking hasp.
   b. One – 1inch NPT high temperature in-line type electrode assembly.
   c. One - 1/2inch NPT 250 psig., motorized blowdown ball valve with carbon steel body, 316 stainless steel ball and stem, and a Worcester actuator. 115v/60Hz.

H. BOILER SAMPLE WATER COOLER:

1. Each Steam Boiler shall be supplied with a Sample Water Cooler to cool water samples down for safe and effective after sample collection. One water Sample Cooler for each steam boiler shall be supplied, rating of 200 psig and steam coil rated at 1,500 psig. The water sampler shall be capable of delivering .3 gpm of 600 degrees F cooled sample water with an exit temperature of 100 degrees F. Proper valves on sample inlet and cooling water inlet plus coil sample outlet and shell outlet will be supplied by mechanical contractor.

I. BOILER WATER TEST KIT:

1. Provide boiler test kits, including spare reagents, or as recommended by the boiler water treatment contractor for determining water conditions of the boiler makeup water, boiler water and condensate water systems.

J. BOILER CHEMICALS:

1. Provide one year supply of Steam Boiler and Condensate chemicals, as recommended by the boiler water treatment contractor.

## 2.5 WATER CONDITIONERS:

A. COMMERCIAL WATER SOFTENER (STEEL TANKS):

1. Provide a single vertical tank as specified below with a [___] inch side shell and [___] inch barrel. The tank shall be of the vertical down flow pressure type with automatic controls to operate on the sodium cycle. The influent water has a hardness of [__] grains per gallon. The system shall be capable of delivering soft water at [_____] gpm continuously with a pressure drop not to exceed 15 psig. The influent and effluent face piping and valves shall be [_____] inches in size. The mineral tanks shall be constructed of low quality carbon steel, having an operating pressure of 125 psig and hydrostatic tested at a pressure of 50 percent in excess of the operating pressure.
   a. ASME Compliance: Construct softener tanks in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. Provide stamp and certification.

b. NSF Compliance: Construct and install water conditioners in accordance with NSF Standard 44 "Cation Exchange Water Softeners Relating to Supplementary Treatment of Potable Water."
c. Mineral Standard: Provide mineral products acceptable under state and local public health control regulations.
d. Tanks Less Than 20inch Diameter: Provide two 4inch diameter (or 4inch x 6inch elliptical) hand-holes, one in top head and one in lower side shell.

OR

Tanks 24inch Diameter and Larger: Provide an 11inch x 15inch manhole, in the top head. The tank side shall be double butt welded with no un-welded or open seams on the interior of the tank. The tank shall also be provided with two lifting lugs to facilitate the handling and positioning of the equipment.

e. Support Legs: Construct legs of structural steel angle with foot pads. The legs shall be designed to properly support the softener tank under dynamic loading. Stirrup legs will be unacceptable.
f. Finish: The tank shall be internally sand blasted and lined with a phenolic epoxy, applied eight to ten mils thick. The tank shall be externally painted with a rest inhibiting primer 2-3 mils dry film thickness with an enamel overcoat.
g. Freeboard: Provide minimum freeboard of 50 percent of the mineral bed depth to allow for adequate resin expansion during backwash.

2. Upper Distribution: The tank shall be equipped with a Schedule 80 PVC upper distributor sized to match the face piping of the softener. The distributor design shall be a 4-point splash dome system, capable of distributing the water evenly over the resin bed.

3. Lower Distribution: The tank shall be equipped with a "Schedule 80 PVC header/lateral lower distributor sized to match the face piping of the softener. The equally spaced laterals shall have slot openings of 0.01inch. The distribution system shall be imbedded in a 9inch layer of washed 1/4inch x 1/8inch gravel to support the resin bed, with a 3inch layer of coarse silica sand on top. The Mechanical Contractor shall be responsible for installing the support gravel and sand under the supervision of the Water Softener Manufacturer.

4. Controls: The system controls shall have adjustable duration of the various steps in regeneration and shall allow for push button start, as well as complete manual override operations. Softener regeneration shall be initiated by:

a. One of two electronic register head water meters that will produce an electrical signal to indicate need for regeneration upon reaching hand set gallonage. Design so signal will continue until automatically reset. Meter shall be capable of indicating rate of flow and total flow.

OR

One single water meter in a common outlet header, that will automatically regenerate each softener at a pre-set gallonage and will diver water flow to the other unit. Meter shall be capable of indicating rate of flow and total flow.

b. Provide electrical lockouts on multiple units to prevent more than one softener from regenerating at any one time.

OR

An electric time clock, which will initiate regeneration at any hour of day and any day of the week.

5. Main operating Valve: Provide industrial automatic multi-port diaphragm type, slow opening and closing control valve free of water hammer. The valve shall be diaphragm powered and hydraulically operated with a position indicator to indicate position of main operating valve. Dissimilar metals shall be isolated within the valve. Provide a valve that requires no special tools for service. Equip valve with internal automatic self-adjusting brine injector to draw brine and rinse at constant rate independent of pressure. Provide single units with internal automatic by-pass of untreated water during regeneration.

6. Five independent Aqua-Matic Series 420 diaphragm valves for regeneration, shall be provided. Diaphragm valves are to be constructed of cast iron with a 125 psig rating. The valves shall be hydraulically powered, having an upper and lower chamber for power opening and closing, and shall not utilize springs in their operation.

7. Mineral Standards: Provide mineral products acceptable under state and local public health control regulations.
   a. The softener shall be provide with [ ] cubic feet of Purolite C-100 cation exchange resin, having a minimum exchange capacity of 30,000 grains when regenerated with 15 lbs. of salt per cubic foot. The media shall be of proper particle size (not more than 4percent through 40 mesh U.S. standard screens, wet screening), and will contain no agglomerates, shells, plates, or other shapes which might interfere with the normal function of the water softeners. The media shall be installed in the field by the mechanical contractor, under the supervision of the softener manufacturer.

8. Brine System: Provide a single brine measuring and dry salt storage tank with salt platform sufficiently sized for at least 4 regenerations at full salting. Construct tank of 3/16inch thick fiberglass or 3/8inch thick molded polyethylene with cover. Equip brine tank with float-operated plastic fitted brine valve for automatic control of brine withdrawn and fresh water refill.

9. Accessories: Provide the following:
   a. Pressure gauges for hard water inlet and soft water outlet.
   b. Sampling cocks for hard water inlet and soft water outlet for each tank.
   c. Provide complete water testing set for hardness.

B. COMMERCIAL WATER SOFTENER (FIBERGLASS TANKS):

1. General: Provide a single vertical tank as specified below, with a [ ] inch by [ ] inch diameter mineral tank. The tank shall be of the vertical down flow pressure type with automatic controls to operate on the sodium cycle. The influent water has a hardness of [ ] grains per gallon. The system shall be capable of delivering soft water at [ ] gpm continuously with a pressure drop not to exceed 15 psig. The influent and effluent piping and valves shall be [ ] inches in size. The mineral tanks shall be of one piece construction throughout, with no seams, no welds, and no joints. The tank shall have an operating pressure of 150 psig at 120 degrees F.
   a. NSF Compliance: Construct and install water conditioners in accordance with NSF Standard 44 "Cation Exchange Water Softeners Relating to Supplementary Treatment of Potable Water."
   b. Mineral Standards: Provide mineral products acceptable under state and local public health control regulations.
   c. Freeboard: Provide minimum freeboard of 50 percent of the mineral bed depth to allow for adequate resin expansion during backwash.

2. Controls: The system controls shall have adjustable duration of the various steps in regeneration and shall allow for push button start, as well as complete manual override operations. Softener regeneration shall be initiated by:
   a. One of two electronic register head water meters that will produce an electrical signal to indicate need for regeneration upon reaching hand set gallonage. Design so signal will continue until reset. Meter shall be capable of indicating rate of flow and total flow.
      1) Provide electrical lockouts on multiple units to prevent more than one softener from regenerating at any one time.
   b. One single water meter in a common outlet header that will automatically regenerate each softener at pre-set gallonage and divert water flow to the other unit. Meter shall be capable of indicating rate of flow and total flow.
      1) Provide electrical lockouts on multiple units to prevent more than one softener from regenerating at any one time.

3. Main Operating Valve: Provide a 5 cycle diaphragm control valve assembly, with no moving teflon internal "jam resistant" internal part.

4. Mineral Standards: Provide mineral products acceptable under state and local public health control regulations.
   a. The softener shall be provided with [ ] cubic feet of Purolite C-100 cation exchange resin, having a minimum exchange capacity of 30,000 grains when regenerated with 15 lbs of salt per cubic foot. The tank shall be filled with proper particle size media (not more than 4 percent through 40 mesh U.S. standard screens, wet screening), and will contain no agglomerates, shells, plates, or other shapes which might interfere with the normal function of the water softeners.

5. Brine System: Provide a single brine measuring and dry salt storage tank sized for at least 4 regenerations at full salting. The brine tank shall be constructed from rigid polyethylene with a special built-in salt grid system and polyethylene cover. Equip brine tank with float-operated plastic fitted brine valve for automatic control of brine withdraw and fresh water refill.

## 2.6 FILTERING SYSTEM:

A. COMMERCIAL FILTER:

1. Provide a single vertical tank with a [ ] inch barrel. The tank shall be of the vertical down flow pressure type with automatic controls to operate on:
   a. Push button control.
   b. Pressure differential.
   c. Time clock.
   d. Water meter.

2. The system shall be capable of delivering filtered water at [ ] gpm continuously with a pressure drop not to exceed 15 psig. The influent and effluent face piping and valves shall be [ ] inches in size. The filter media tanks shall be constructed of low quality carbon steel, having and operating pressure of 125 psig, and hydrostatically tested at a pressure of 50percent in excess of the operating pressure.
   a. ASME Compliance: Construct filter tanks in accordance with ASME Boiler and Pressure Vessel Code, Section VIII. Provide stamp and certification.
   b. NSF Compliance: Construct and install filters in accordance with NSF Standards, relating to supplementary treatment of potable water.
   c. Mineral and Media Standards: Provide mineral products acceptable under state and local public health control regulations.

d. Tanks Less Than 20inch Diameter: Provide two 4inch diameter (or 4inch x 6inch elliptical) hand-holes, one in top head and one in lower side shell.

OR

Tanks 24inch Diameter and Larger: Provide and 11inch x 15inch manhole, in the top head. The tank side shall be double butt welded with no un-welded or open seams on the interior of the tank. The tank shall also be provided with two lifting lugs to facilitate the handling and positioning of the equipment.

e. Finish: The tank shall be internally sand blasted and lined with a phenolic epoxy, applied eight to ten mils thick. The tank shall be externally painted with a rust-inhibiting primer 2 - 3 mils dry film thickness with an enamel overcoat.

f. Freeboard: Provide minimum freeboard of 50% of the filter and mineral bed depth to allow for adequate expansion during backwash.

3. Upper Distribution: The tank shall be equipped with a "Schedule 80" PVC upper distributor sized to match the face piping of the softener. The distributor design shall be a 4-point splash dome system, capable of distributing the water evenly over the filter media.

4. Lower Distribution: The tank shall be equipped with a "Schedule 80" PVC header/lateral lower distributor sized to match the face piping of the softener. The equally space laterals shall have slot openings of 0.01inch. The distribution system shall be imbedded in a 9inch layer of washed 1/4inch x 1/8inch gravel to support the filter media bed. The Mechanical Contractor shall be responsible for installing the support gravel and media under the supervision of the Filter Manufacturer.

5. The system controls shall have adjustable duration of the various steps in backwashing, and shall allow for push button start, as well as complete manual override operations. The filter backwash shall be initiated by:

a. Push button control: Provide contacts on the filter controller for remote push button starting of the backwash cycle of the filter.

OR

Pressure Differential: Provide a differential pressure switch between the influent and the effluent of the filter, to start backwash cycle of the filter. The differential switch shall be rated at [ ] psig and have an adjustable differential of [ ] psig.

OR

Time Clock: Provide an electric time clock, which will initiate the backwash cycle of the filter.

Water Meter: Provide two electronic register head water meters that will produce an electrical signal to indicate need for backwashing of the filter upon reaching a hand-set gallonage. Design so signal will continue until automatically reset. Meter shall be capable of indicating rate of flow and total flow.

1) Provide electrical lockouts on multiple units to prevent more than one softener from backwashing at any one time.

OR

Water Meter: Provide one single water meter in a common outlet header that will automatically backwash each softener at a pre-set gallonage and will divert water flow to the other unit. Meter shall be capable of indicating rate of flow and total flow.

2) Provide electrical lockouts on multiple units to prevent more than one softener from regenerating at any one time.

6. Main Operating Valve: Provide industrial automatic multi-port diaphragm type, slow opening and closing control valve free of water hammer. The valve shall be diaphragm powered and hydraulically operated with a position indicator to indicate position of main operating valve. Dissimilar metals shall be isolated within the valve. Provide a valve that requires no special tools for service. Provide single units with internal automatic bypass of untreated water during regeneration.

7. Five independent Aqua-Matic Series 420 diaphragm valves for media backwash, shall be provided. Diaphragm valves are to be constructed of cast iron with a 125 psig rating. The valves shall be hydraulically powered having an upper and lower chamber for power opening and closing, and shall not utilize springs in their operation.

8. Media Standards: Provide media products acceptable under state and local public health control regulations.
   a. The filter shall be provided with [ ] cubic feet of [ ] filter media.
   b. The filter media shall be installed in the field by the mechanical contractor, under the supervision of the manufacturer.

9. Accessories: Provide the following:
   a. Pressure gauges for influent and effluent of filter.

PART 3 - EXECUTION

3.1 CLEANING OF PIPE LINES AND BOILERS:

A. The water treatment contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the chilled and/or heating piping.

B. The system to be cleaned shall be filled with a solution of 10% by weight of a heavy duty alkaline liquid cleaner. The cleaner shall be capable for wetting and penetrating heavy soil deposits of oil or grease, and keeping these products in suspension, for removal through a Filter Feeder.

C. The cleaning solution shall be circulated for a minimum of 8 hours, with the Filter Feeder being back-washed as required to remove solids which have been cleaned from the system.

D. At the end of the cleaning period, the alkalinity in the system shall be reduced to the pH of the incoming raw water. The system shall then be chemically treated as specified. In no case shall the system being cleaned be left in an untreated condition for more than 8 hours.

E. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the system was cleaned as specified.

OR

F. The Water Treatment Contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the chilled and/or heating piping.

G. The system to be cleaned shall be filled with a solution of 10 percent by weight of a heavy duty alkaline liquid cleaner. The cleaner shall be capable of wetting and penetrating heavy soil deposits of oil or grease, and keeping these products in suspension, for removal through flushing the system to drain.

H. The cleaning solution shall be circulated for a minimum of 8 hours. At the end of the eight hours, the system shall be flushed to drain, and then refilled with fresh water, taking care to remove any entrapped air from the system.

I. At the end of the cleaning period, the system shall be chemically treated as specified. In no case shall the system being cleaned be left in an untreated condition for more than 8 hours.

J. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the system was cleaned as specified.

3.2 CLEANING OF STEAM BOILERS:

A. The Water Treatment Contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the steam boilers.

B. The boiler manhole/hand holes should first be opened and the boiler drum visually inspected for dirt. Any dirt should be removed by hand.

C. With the manhole open, the boiler should be operated at a rolling boil with a heavy duty alkaline cleaner, capable of wetting and penetrating heavy soil deposits of oil or grease, and removing them from the system. The solution shall remain in the boiler for a period of 8 hours to assure good circulation and boil out.

D. At the end of the boil out period, slowly cool the boiler. Completely drain and flush all internal parts of the boiler with a high pressure hose. Inspect all internal parts for cleanliness and freedom from oil and/or grease, and reinstall the manhole cover.

E. At the end of the boil out, the boiler should be filled with fresh treated water and operated for 8 hours, with the condensate being wasted to drain.

F. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the boilers were cleaned as specified.

3.3 CLEANING OF OLD RUSTY SCALED HYDRONIC SYSTEMS:

A. The Water Treatment Contractor shall be responsible for furnishing the cleaning material and supervising the chemical cleaning of the chilled and/or heating piping.

B. A Filter Feeder shall be installed across the suction and pressure side of the circulated water system to be cleaned.

C. The system to be cleaned shall be filled with a solution of 1000 ppm HEDP (phosphonate), and the pH adjusted between 7 to 8.5 to break up existing corrosion, which will be removed through the Filter Feeder, as outlined in B. above. This material should be continuously circulated throughout the system over a period of two weeks, and the Filter Feeder flushed as required, with the understanding that the chemical will also remove some new metal from the existing pipes.

D. At the end of two weeks, the chemicals should be removed from the system, and the system flushed out with fresh city water and chemically treated with an inhibitor as specified. In NO case shall the system be left in an untreated condition for more than 8 hours.

E. At the conclusion of the cleaning operation, the Water Treatment Contractor shall certify in writing that the system was cleaned as specified.

3.4 CHLORINATION:

A. Acceptable products are:

| | |
|---|---|
| Liquid Chlorine | [Fed. Spec. BB-C120B] |
| Hypochlorite | [Fed. Spec 0-C-114, Type 11, Grade B]<br>[Fed. Spec. 0-S-60D, Grade A or B] |

B. After all pressure tests have been performed and piping has been flushed clean, the chemical treatment contractor shall be responsible for sterilizing the domestic water lines and fire protection lines.

C. Chlorination procedures shall comply with local code and health department regulations.

1. The Mechanical Contractor shall inform the General Contractor that the water system is to be chlorinated 48 hours in advance, so that arrangements can be made for other trades not to use the water.

2. Before commencing the chlorination process, the Water Treatment Contractor shall post signs at each water fountain, and on each restroom door, stating that the water is not fit for drinking, and that the water is being chlorinated.

3. Introduce sufficient chlorine into the domestic water system to provide a dosage of not less than 50 parts per million at each faucet and valve. The chlorine solution shall then be allowed to stand for a minimum of 24 hours in the system.

4. At the end of 24 hours test shall be made for residual chlorine at the extreme end of the system from the point where chlorine was introduced. If chlorine residual is less than 10 ppm, the chlorination procedure shall be repeated.

5. Flush the system with a clean supply of water until the chlorine residual in the system is reduced to less than 1 ppm, or to the chlorine residual of the supply water. During flushing, each faucet and valve in the system shall be opened and closed a minimum of 4 times.

6. After 24 hours, the water treatment representative will have samples taken and tested by an independent laboratory. The system must be free of bacteriological contamination. If the system is contaminated, it shall be re-chlorinated until a satisfactory test is made.

7. The Water Treatment Contractor shall write a letter, informing the Mechanical Contractor that the building has been successfully chlorinated, and that the water is fit for human consumption.

3.5 TESTING

A. Closed Systems:

1. Provide a Nitrite "Drop Test" kit for determining the level of Nitrite or Molybdate in the closed system.

B. Open Systems:

1. Provide the following test equipment and test kits:

2. One conductivity meter and three ranges covering 0 to 10,000 ppm/TDS and with automatic temperature compensation.

3. One "Drop Test" kit for determining the level of inhibitor being used in the cooling tower water.

4. One "Drop Test" for determining the chloride level of the water in the cooling tower and the makeup water.

C. Steam Boilers:

1. Provide a Testmaster Senior test cabinet, consisting of 4 automatic burettes in a wall-mounted cabinet with internal 115 volt light. Included with the cabinet shall be all components, glass ware, etc. necessary to test for pH, sulfite, P & M Alkalinity, phosphates, chloride, and hardness. One TDS conductivity meter with three ranges covering 0 to 10,000 ppm/TDS temperature compensated.

2. The test cabinet shall include an initial supply of all reagents needed to perform the above tests, with a supply of boiler log sheets on which to record the test results, and a hard back three ring binder with testing instructions.

3.6 COUPON RACKS:

A. Coupon Rack for Closed Systems:

1. Install as shown on the drawings two coupon holders between the low and high pressure of the circulating pump. The coupon holders shall be isolated with shut off valves for removing and inspecting the coupons.

When the system is ready for startup, the Water Treatment Contractor shall install two pre-weighted coupons, one copper, and the other steel in the above coupon holders, noting time and date. At the end of 90 days, the coupons shall be removed, noting the time and date, re-weighed, and inspected, with a report being sent to the mechanical contractor, for distribution to the proper people, showing the condition of the system being treated.

B. Coupon Rack for Open Systems:

1. Install as shown on the drawings a three station coupon rack, built to ASME specifications and as shown on the drawing, made from 3/4inch PVC Schedule 80 pipe. The coupon holders shall consist of nylon screw and nut for holding the coupon, PVC water inlet ball shut off valve, 3/4inch PVC pipe, and the coupon rack shall be pre-mounted on an unpainted plywood backboard.

When the system is ready for startup, the Water Treatment Contractor shall install three pre-weighted copper coupons in the above coupon holders, noting time and date. One coupon each, will be removed at the end of 60, 90, and 120 days, noting time and date, reweighed, and inspected, with a report being sent to the mechanical contractor, for distribution to the proper people showing the condition of the system being treated.

3.7 INSTALLATION:

A. Coordination where installation of Water Treatment equipment in piping systems is required with the other work (plumbing and heating piping) as necessary to interface components of water treatment equipment. Provide installation instructions to those firms providing installation.

B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

2. Install pressure gauges, valves, and controls furnished by manufacturer, in accordance with manufacturer's instructions.

## 3.8 INSTALLATION OF WATER CONDITIONERS:

A. General: Install water conditioners where indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices, to ensure that water conditioners comply with requirements and service for the intended purposes.

B. Access: Provide access and service space around and over water conditioners as indicated, but in no case less than that recommended by manufacturer.

C. Support: Provide 4inch high concrete pad under water conditioners. Plumb and level units.

D. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

E. Piping Connections: Provide shutoff valves and unions or flanges on water connections. Pipe drain to nearest floor drain of suitable size for the backwash of the softener.

## 3.9 INSPECTION:

A. Examine areas and conditions under which water treatment systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

## 3.10 FIELD QUALITY CONTROL:

A. Sample water softener effluent at one-week intervals after start-up for period of 3 weeks and prepare test report on the conditions of the water.

## 3.11 SYSTEM START-UP:

A. The Water Treatment Supplier shall put the system into operation, and make adjustments necessary for proper operation.

B. The Water Treatment Supplier shall provide a written report to the Division 22 Contractor indicating that the start-up has been completed and that all Water Treatment Equipment is operating properly.

## 3.12 TESTING AND CLEANING:

A. Sample all treated water systems at one-week intervals after start-up for a period of 4 weeks, and prepare certified test report for each system being treated.

B. Start-up test, and adjust water conditioners in presence of manufacturer's authorized representative. Operate units including regeneration, back washing, rinsing and flushing. Adjust unit to maintain required steady state effluent water quality.

C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.13 EXTRA STOCK:

A. Not required, aside from startup salt.

3.14 CLOSEOUT PROCEDURES:

A. Provide services of manufacturer's technical representative for one 8 hour day to instruct Owner's personnel in operation and maintenance of water treatment systems.

1. Schedule training with Owner, with minimum 7 day notice to Contractor and Engineer.

**END OF SECTION 23 25 00**

# SECTION 23 31 13 - METAL DUCTWORK

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK:

Edit Note: Verify that duct pressure class is scheduled on the drawings. Pressure class is NOT called out in the specifications.

A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

| DUCT SERVICE | TYPE/CONSTRUCTION |
|---|---|
| Supply air between fan and terminal boxes (medium and high). | Galvanized steel, spiral, round or oval /rectangular. |
| Rectangular supply air from discharge of terminal box/fan to air devices (low pressure). | Galvanized sheet metal /spiral round and oval or rectangular (lined as noted on drawings.) |
| Return air ductwork. | Galvanized steel (lined where noted on drawings); factory or shop fabricated.). |
| General building exhaust. | Galvanized sheet metal (lined as noted on drawings); factory or shop fabricated.). |
| Transfer ducts. | Internally lined galvanized sheet metal as described above for low pressure supply; factory or shop fabricated. |
| Sound elbows for R.A. grilles | Galvanized sheet metal (internally lined).<br><br>OR<br><br>Fibrous glass ductboard |
| Laboratory general exhaust, fume hood exhaust risers, mains and branch ducts including fume hoods. | PVC coated ductwork; factory or shop fabricated. |
| Outdoor air intake ductwork. | Galvanized sheet metal, rectangular, factory or shop fabricated. |
| Radioisotope exhaust. | 316 stainless steel all welded construction; factory or shop fabricated. |
| Bio-hazard room air and Bio-safety cabinets exhaust air. | 304 stainless steel all welded construction; factory or shop fabricated. |

| | |
|---|---|
| Dishwasher exhaust.<br>Cagewash, tunnelwash exhaust.<br>Autoclave | 316 stainless steel all welded construction<br><br>***Edit Note: check with Owner for alternate construction.***<br><br>PVC coated with sealant, hardcast and tape.<br><br>OR<br><br>Aluminum with silicone sealant. |
| Kitchen grease exhaust. | Concealed From View: Min 16 GA, carbon steel, all welded construction.<br>Exposed To View: Type 304 stainless steel, min. 18 GA all welded construction, with welds ground smooth for a #4 finish. |
| Perchloric Exhaust. | 316 stainless steel with all welded construction, all welds ground smooth. |
| Below grade ductwork. | PVC coated. |
| Exterior uninsulated ductwork. | Aluminum or 304 SS or painted galvanized |
| Shower, locker room exhaust. | Aluminum with silicone sealant. |

B. Exterior insulation of metal ductwork is specified in other Divisions 20 and 23 sections, and is included as work of this section.

C. Refer to other Division 23 sections for ductwork accessories.

D. Refer to other Divisions 23 sections for fans and air handling units.

E. Refer to other Division 23 sections for testing, adjusting, and balancing of metal ductwork systems.

1.2 DEFINITIONS:

A. Low Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to 2" or less, positive or negative pressure class.

B. Medium or High Pressure Duct: Duct required by the drawings, specifications, or referenced standards to be constructed to greater than 2" positive or negative pressure class.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.

C. References to SMACNA, ASHRAE and NFPA are minimum requirements, the Contractor shall fabricate, construct, install, seal and leak test all ductwork as described in this specification and as shown on the drawings, in addition to these minimum standard references.

D. Codes and Standards:

1. SMACNA Standards: Comply with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible" for fabrication and installation of metal ductwork. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.

2. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" and NFPA 90B "Standard for the Installation of Warm Air Heating and Air Conditioning Systems".

E. SMACNA Industrial Construction Standards.

F. Field Reference Manual: Have available for reference at project field office, copy of SMACNA "HVAC Duct Construction Standards, Metal and Flexible", and SMACNA "HVAC Air Duct Leakage Test Manual".

1.4 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for ductwork materials and products. Provide product data for manufactured joining systems. Include sound attenuation by octave band for sound rated flexible duct.

| * * * Edit for each project * * * |
|---|

B. Shop Drawings: Submit 1/4" scaled fabrication and layout drawings of metal ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

C. Record Drawings: At project closeout, submit record drawings of installed systems, in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

D. Maintenance Data: Submit maintenance data and parts lists for metal ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings. By providing end caps on all open sections, bagging small fittings, surface wrapping and shrink wrapping.

B. Storage: Store ductwork inside elevated from floor on pallets. At no time shall the inside surfaces be exposed, or stored with open ends and protect from weather.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Duct Liner:
   a. Owens-Corning Fiberglas Corp.
   b. CertainTeed Corp.
   c. Manville Products Corp. (Schuller)
   d. Pittsburgh Corning Corp.

2. Flexible Ducts:
   a. Flexmaster
   b. Thermaflex

3. Duct Take Off Fittings
   a. Hercules Industries
   b. Flexmaster
   c. Thermaflex
   d. Ominair

4. Round and flat oval Ductwork (low, medium, and high pressure):
   a. Semco Mfg., Inc.
   b. United Sheet Metal Div., United McGill Corp.
   c. Sheet Metal Products Co.
   d. Spiral Pipe of Texas, Inc.
   e. Hercules Industries

5. PVC Coated Ducts:
   a. Foremost
   b. Norlock
   c. Semco

## 2.2 DUCTWORK MATERIALS:

A. Exposed Ductwork Materials: Where ductwork is exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains, dents, discolorations, and other imperfections, including those which would impair painting.

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A 527, lock-forming quality; with G 90 zinc coating in accordance with ASTM A 525; and mill phosphatized for exposed locations. Provide flat seam construction where standing seams are a hazard to the Owner's operation personnel.

C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A 167; Type 304 or 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.

D. Aluminum Sheet: Where indicated, provide aluminum sheet complying with ASTM B 209, Alloy 3003, Temper H14.

E. Uncoated carbon steel shall comply with ASTM A569, hot rolled steel sheet.

## 2.3 PVC COATED DUCTWORK:

A. Steel:

1. Hot dipped galvanized steel, lock forming quality.

2. Pretreatment: Ductwork shall be cleaned and treated to accept a primer.

3. Primer: Reverse rollcoat application of primer.

4. Bake: Primer shall be oven cured.

5. Quench: Water drenched and air dried.

6. PVC: Film polyvinyl chloride (PVC) dispersion.

7. Finish: Bake.

8. Film Properties - PVC:
   a. Flexibility: 180°OT bend with no peeling.
   b. Color: White - Olson standard.
   c. Surface: Smooth, non-embossed or plenished. Free of blisters, sags, stringers, and voids.
   d. Weight/Density: .035 lbs./sq. ft. @ 5 mils.
   e. Hardness: 90 units A scale, Shore - Durometer, minimum.
   f. Gloss: Medium.

Edit consistent with duct service table.

B. For laboratory general exhaust and fume hood exhaust, inside of duct shall have 4 mil thickness with 4/1 mil exterior.

C. For below grade ductwork, exterior of duct shall have 4 mil thickness with 4/1 mil interior coat.

## 2.4 MISCELLANEOUS DUCTWORK MATERIALS:

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 deg. change of direction per section. Unless specifically detailed otherwise, use 45 deg. laterals and 45 deg. elbows for branch takeoff connections. Where 90 deg. branches are indicated, provide conical type tees.

C. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of thickness indicated.

1. Unless otherwise noted, provide 1" thick, 1-1/2 lb density, fiberglass duct liner meeting ASTM C1071 Type I, NFPA 90A and 90B and TIMA (AHC-101) with minimum NRC (noise reduction coefficient) of 0.70 as tested per STM C 423 using an "A" mounting with minimum "K" factor of 0.25. Lining shall be U.L. approved, made from flame attenuated glass fiber bonded with a thermosetting resin with acrylic smooth surface treatment and factory applied edge coating. Materials shall conform to revised NFPA No. 90A Standards, with a maximum flame spread of 25 and maximum smoke development of 50.

Edit Note: Show rigid liner in plenums, casings and other areas subject to repeated entry and potential for damage. Also, use where greater than 1" liner is desired, as the rigid product resists de-lamination.

2. Provide rigid plenum liner board where indicated. Rigid liner shall be [1", 1-1/2", 2"] thick, 3 pounds per cubic foot, glass fiber bonded with thermosetting resin, with an acrylic coating, conforming to NFPA 90 and ASTM C1071.
   a. Schuller/Manville Permacote Linacoustic R-300.

D. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".

E. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/ installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork. All PVC coated exhaust ductwork shall be sealed with an approved chemical resistant sealant as manufactured by Foremost Co. PCD No. 8 duct sealer and wrap with hardcast tape. For outdoor ductwork, sealant shall also be U.V. resistant and weather resistant.

G. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

1. For exposed stainless steel ductwork, provide matching stainless steel support materials.

2. For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.

H. Flexible Ducts: Flexible air ducts shall be listed under UL-181 standards as Class I Air Duct Material and shall comply with NFPA Standards 90A and 90B. Minimum operating pressure rating shall be 6" W.C. through a temperature range of -20$^{o}$ to 150$^{o}$F; minimum working velocity rating shall be 4000 f.p.m. Contractor shall assume responsibility for supplying material approved by the authority having jurisdiction.

1. All insulated flexible ducts shall be constructed of a metalized ripstop reinforced laminate inner core, 1" thick, 3/4 lb. density fiberglass insulation with "C" factor of 0.23 or less and an outer jacket made exclusively of fire retardant reinforced aluminized material.
   a. Flexmaster Type 5M.

2. All/Where shown on drawings flexible duct shall be rated for sound attenuation. Inner core shall be black CPE supported by a galvanized steel helix, with 1" C=.23 or less insulation and metalized reinforced outer jacket. Sound attenuation shall be as scheduled below:

| INSERTION LOSS, PER 10' SECTION, ZERO FLOW | | | | | | |
|---|---|---|---|---|---|---|
| Octave Band | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| IL (dB) 8" dia. | 13 | 31 | 36 | 35 | 38 | 21 |

   a. Flexmaster Type 8M

3. Non-insulated flexible ducts shall be constructed from dead soft aluminum sheet, spiral corrugated, or aluminum construction over a steel spring helix.

I. Duct Take-Off Fittings to Individual Air Inlets & Outlets: Provide conical spin-in fittings at flexible or round sheet metal duct takeoffs. Where specifically shown on drawings, where the duct dimension does not allow for a conical spin-in, or at Contractor's option, provide 45° inlet rectangular to round duct take off fittings, with factory applied gasket. Fittings shall include

butterfly type manual volume damper with regulator, and dual locking device. Dual locking device shall consist of two shaft mounted wing nuts, one on each side of the damper. Wing nuts shall tighten on shafts to lock butterfly in place. Shafts shall be solid metal; rolled metal shafts are not acceptable.

Hercules Model 9000 (conical)
Hercules Model 6000 (straight-

J. Underslab Ducts: For ductwork placed in concrete slabs, or under slabs on grade, fabricate PVC coated ductwork.

K. See detail on drawings for installation requirement.

L. All fasteners and hardware for stainless steel ductwork shall be made of stainless steel.

2.5 FABRICATION:

A. Fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match- mark sections for reassembly and coordinated installation.

B. Fabricate ductwork of gauges and reinforcement complying with SMACNA "HVAC Duct Construction Standards". Minimum 26 GA where ducts are within corridors.

C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.

D. If manufacturer flange joining systems are used as part of the reinforcing, the EI rating and rigidity class shall be equivalent to the reinforcing requirements of the standard. Submit manufacturer's product data.

E. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.

F. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to 1.5 times the associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 deg. for contracting tapers and 20 deg. for expanding tapers. Divided flow fittings shall be 45° inlet branches, stationary splitters and elbows, or as shown on drawings.

G. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Section 23 33 00 "Ductwork Accessories" for accessory requirements. All exhaust ductwork accessories (including dampers, turning vanes, access doors, etc.) shall be Heresite or PVC coated. All stainless steel ductwork shall have stainless steel accessories (including dampers, turning vanes, access doors, etc.) construction.

H. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners. Provide sheet metal nosing on all leading edges preceded by unlined duct, at duct openings, and at fan or terminal unit connections.

2.6 LOW PRESSURE ROUND DUCTWORK:

A. Material: Galvanized sheet steel complying with ASTM A 527, lockforming quality, with ASTM A 525, G90 zinc coating, mill phosphatized. Spiral lockseam construction. Individual runouts to diffusers may be longitudinal seam.

B. Gauge: 28-gauge minimum for round and oval ducts and fittings, 4" through 24" diameter. Minimum 26 gauge where ducts are within a corridor.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Spot welded and bonded construction.

Edit Note: Edit out "saddle taps" where sheet metal craftsmanship is suspect or Contractor selection is not under our control.

D. Divided Flow Fittings: 90 deg. tees, constructed with branch spot welded and bonded to duct fitting body, or saddle tap fitting, with minimum 2" flange shaped to fit main duct.

2.7 MEDIUM AND HIGH PRESSURE ROUND AND FLAT OVAL DUCTWORK:

A. General: Provide factory-fabricated duct and fittings.

B. Duct gauges given below are minimum values; in no case shall the duct gauge be less than recommended by SMACNA for the operation pressures of the systems shown on the drawings, (both positive and negative pressures), including proper re-enforcement.

C. Elbows: One piece construction for 90 deg. and 45 deg. elbows 14" and smaller. Provide multiple gore construction for larger diameters with standing seam circumferential joint. Radius to centerline shall be 1.5 times duct diameter. Fully welded construction.

Edit Note: Edit out "saddle taps" where sheet metal craftsmanship is suspect or Contractor selection is not under our control.

D. Divided Flow Fittings: Full body fittings with solid welded construction or solid welded saddle tap fittings with a minimum 2" flange shaped to fit the main duct. Provide conical laterals, conical tees, 45° inlet tees, wye fittings, or as shown on drawings. Straight tap tees shall not be used.

E. Round Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gauges listed.

| Diameter | Minimum Gauge | Method of Manufacture |
|---|---|---|
| 3" to 14" | 26 | Spiral Lockseam |
| 15" to 26" | 24 | Spiral Lockseam |
| 27" to 36" | 22 | Spiral Lockseam |
| 37" to 50" | 20 | Spiral Lockseam |
| 51" to 60" | 18 | Spiral Lockseam |
| Over 60" | 16 | Longitudinal Seam |
| | 18 | Spiral Lockseam |

1. Provide locked seams for spiral duct; fusion-welded butt seam for longitudinal seam duct. Provide internal stiffener rings and external reinforcement as required to meet operating static pressures scheduled on drawings.

2. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

| Diameter | Minimum Gauge |
|---|---|
| 3" to 14" | 24 |

| | |
|---|---|
| 15" to 26" | 22 |
| 28" to 50" | 20 |
| 52" to 60" | 18 |
| Over 62" | 16 |

F. Flat-Oval Ductwork: Construct of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, in minimum gauges listed.

| Maximum Width | Minimum Gauge |
|---|---|
| Under 25" | 24 |
| 25" to 48" | 22 |
| 49" to 70" | 20 |
| Over 70″ | 18 (or 16 GA Longitudinal welded seam) |

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams.

| Maximum Width | Minimum Gauge |
|---|---|
| Under 37" | 20 |
| 37" to 59" | 18 |
| Over 59" | 16 |

G. Internally Insulated Duct and Fittings: Construct with outer pressure shell, 1" thick insulation layer, and perforated inner liner. Construct shell and liner of galvanized sheet steel complying with ASTM A 527, of spiral lockseam construction, use longitudinal seam for over 59", in minimum gauges listed.

| Nominal Duct Diameter | Outer Shell | Inner Liner |
|---|---|---|
| 3" to 12" | 26 ga. | 26 ga. |
| 13" to 24" | 24 ga. | 26 ga. |
| 25" to 34" | 22 ga. | 26 ga. |
| 35" to 48" | 20 ga. | 26 ga. |
| 49" to 62" | 18 ga. | 26 ga. |
| Over 62" | 18 ga. | 22 ga. |

1. Fittings and Couplings: Construct of minimum gauges listed. Provide continuous weld along seams of outer shell.

| Nominal Duct Diameter | Outer Shell | Inner Liner |
|---|---|---|
| 3" to 34" | 20 ga. | 24 ga. |
| 36" to 48" | 20 ga. | 22 ga. |
| 50" to 58" | 18 ga. | 22 ga. |

| | | |
|---|---|---|
| Over 58" | 16 ga. | 22 ga. |

2. Inner Liner: Perforate with 3/32" holes for 22% open area. Provide metal spacers welded in position to maintain spacing and concentricity.

PART 3 - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which metal ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF METAL DUCTWORK:

A. Duct Sealing:

1. Seal all low pressure ducts to SMACNA Seal Class "B".

2. Seal all medium and high pressure ducts to SMACNA Seal Class "A".

B. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling, popping or compressing. Support vertical ducts at every floor.

C. Construct ductwork to schedule of operating pressures as shown on drawings.

D. Inserts: Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

E. Field Fabrication: Complete fabrication of work at project as necessary to match shop-fabricated work and accommodate installation requirements.

F. Routing: Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct useable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

G. Electrical Equipment Spaces: Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

H. Slope shower, locker room, and high moisture ductwork down to air device.

I. Penetrations: Where ducts pass through fire rated walls and do not contain fire or smoke dampers, protect with fire stop material installed in accordance with its listing. Where ducts pass through interior partitions or exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on all four sides by at least 1-1/2". Fasten to duct only. Where ducts penetrate

non-fire rated, mechanical, electrical or acoustically sensitive walls, provide 1/2" to 3/4" annular space between duct and wall, pack annular space with mineral wood insulation, and caulk both sides with non-hardening acoustical sealant.

J. Coordination: Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

K. Installation: Install metal ductwork in accordance with SMACNA HVAC Duct Construction Standards and Industrial Construction Standards.

L. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

## 3.3 INSTALLATION OF DUCT TAKE-OFF FITTINGS:

A. Fully seal all joints.

B. Sheet metal screw regulator arm to duct after balance is complete. Mark and date position of regulator arm.

C. Insulation over regulator arm is not required.

## 3.4 INSTALLATION OF DUCT LINER:

A. General: Install duct liner in accordance with SMACNA HVAC Duct Construction Standards.

## 3.5 INSTALLATION OF FLEXIBLE DUCTS:

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 5' - 0".

B. Installation: Install in accordance with Section III of SMACNA's "HVAC Duct Construction Standards, Metal and Flexible".

## 3.6 GREASE EXHAUST DUCTS:

A. Install in accordance with Uniform Mechanical Code, NFPA 96, and local modifications to those codes. Connect to hoods in accordance with the hood manufacturer's listing.

B. Horizontal duct less than 75 feet in one run shall be pitched at 1/4" per foot towards the hood or a drain point. Those portions over 75 feet shall be pitched at 1" per foot.

Edit Note: Coordinate with Section 23 07 00 and the Architect.

C. See drawings for enclosure requirements.

1. See Section 23 07 00 for blanket type fire-rated enclosure.

2. See Division 9 for shaft wall enclosure systems.

3. Install duct so a minimum of 3" and a maximum of 12" is maintained between duct and enclosure.

D. Use no turning vanes, tie rods, dampers or other internal structures which will collect grease. All changes in direction shall be made with radiused fittings.

E. Provide cleanouts as follows:

1. Cleanouts shall be installed in the side or top of the duct, whichever is more accessible.

2. When installed on the side, the bottom of the opening shall be a minimum of 1-1/2" above the bottom of the duct.

3. Ducts serving hoods with integral fire dampers shall have a clean out opening within 18" of the collar.

4. Horizontal ducts shall either have one opening large enough for personnel entrance or minimum 12" x 6" openings at 12' intervals.

5. Vertical ducts shall either have one opening at the top large enough for personnel entrance and descent or a minimum of 12" x 6" openings at every floor.

6. Openings shall have a flanged frame, extending 1" off the duct wall. Closure panels shall be attached to the flange by means of threaded studs welded to the flange, protruding through holes in the panel and fastened by means of wing nuts. Provide "Fiber Frax" or equivalent high temperature (1500°F) rope type gasket bonded to either the gasket or panel.

7. Provide access doors in the enclosure at all cleanouts.
   a. Use UL listed methods for blanket type fire rated enclosures. See Section 23 07 00.
   b. Use UL listed fire rated access doors in shaft wall enclosures. See Section 08 31 00.

## 3.7 FIELD QUALITY CONTROL:

A. Leakage Tests: Conduct duct leakage test in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than maximum permissible leakage as specified below.

B. General:

1. Ductwork pressure tests shall be observed by Architect/Engineer prior to installation of insulation.

2. Ductwork systems in 3" W.G. pressure class and higher shall be tested in their entirety for leaks. Arbitrary sections of ductwork in 2" W.G. and lower pressure class shall be tested as required by Architect/Engineer.

3. Test Failures: Duct systems shall be repaired if test pressure and leakage requirements are not met or if air noise condition is encountered. Repairs and sealing shall be done with sheet metal, tape, sealant or a combination thereof.

C. Test Equipment:

1. Portable rotary type blower or tank type vacuum cleaner with control damper. Equipment shall have sufficient capacity to properly test reasonably large duct system section.

2. Orifice assembly consisting of straightening vanes and calibrated orifice plate mounted in a straight tube with properly located pressure taps.

3. Two (2) U-tube manometers, one to measure drop across calibrated orifice and one to measure S.P. in duct being tested. Provide low differential pressure Dwyer magna-helic gauges for low leak testing in lieu of U-tube manometers.

4. Provide Dwyer magna-helic gauge with 0-.25" W.C. range for testing 0% leakage ductwork.

D. Testing Pressures and Permissible Leakage:

1. Test pressure shall be equal to the construction class. Negative pressure duct shall be tested at the equivalent positive pressure.

2. Allowable leakage shall be determined from the following equation (or Figure 4-1 in the above referenced Standard):

$F = C_L (P)^{.65}$

Where: F = Allowable leakage factor CFM/100 Sq. Ft.

$C_L$ = Leakage Class

P = Test pressure inches W.C.

3. Leakage class shall be as follows:
   a. Seal class A, Round or oval duct, $C_L = 3$.
   b. Seal class A, Rectangular duct, $C_L = 6$.
   c. Seal class B, Round or oval duct, $C_L = 6$.
   d. Seal class B, Rectangular duct, $C_L = 12$.
   e. Seal class C, Round or oval duct, $C_L = 12$.
   f. Seal class C, Rectangular duct, $C_L = 24$.

4. Record all tests using the procedure and forms in the above referenced standard.

5. All plenums and casings shall be tested by pressuring to the pressure class indicated and visually observing leakage and panel deflection.
   a. No noticeable leakage shall be allowed.
   b. Deflection shall be less than 1/8" per foot.

| * * * Select if required * * * |
|---|

6. All bio-safety room, cabinet exhaust and radioisotope exhaust shall be leak tested at [4"] S.P. at 0% leakage.

7. Kitchen exhaust shall be leak tested at [ ] S.P. at [ ]% leakage.

## 3.8 EQUIPMENT CONNECTIONS:

A. General: Connect metal ductwork to equipment as indicated; provide flexible connection for each ductwork connection to equipment mounted on vibration isolators and/or equipment containing rotating machinery. Provide access doors where required for service, maintenance and inspection of ductwork accessories. See Section 23 33 00.

## 3.9 ADJUSTING AND CLEANING:

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances. Where ductwork is to be painted, clean and prepare surface for painting.

B. Protection:

1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.

2. Cover all stored ducts to protect from moisture, dust or debris.

3. Maintain a cover on all ends of installed ductwork at all times, except when actually connecting additional sections of duct.

C. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.

1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.

2. Ductliner in installed ductwork which has become wet must be completely removed and replaced.

3. Torn ductliner may be repaired by coating with adhesive if damage is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

| * * * Select as required * * * |
|---|

D. For sensitive areas including but not limited to operating rooms, bone marrow transplant rooms, tissue culture rooms, ICU rooms, clean rooms, etc. Scrub all ductwork inside and out with sterilizing alcohol. Keep all ductwork capped and sealed in plastic covering at all times except during installation of that section.

E. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.

F. Balancing: Refer to Section 23 05 93 "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork; not work of this section. Seal any leaks in ductwork that become apparent in balancing process.

## 3.10 INSPECTION:

A. After completion of the ductwork installation and after the Test and Balancing work, a minimum of 10% of the installed length of the supply duct system shall be inspected by an independent company specializing in such work. Inspection shall be performed using fiber optic video equipment and other appropriate techniques.

1. Sections to be inspected shall be determined by the Engineer.

B. A report, including a recording on DVD of the video, shall be submitted to the engineer. The report shall document the findings of the inspection, listing any areas of concern, including evidence of water, dust, dirt and construction debris.

C. If, in the opinion of the Engineer and the Inspection company, the supply ductwork is unacceptably contaminated, the supply duct system shall be cleaned. Additional inspections shall be performed, including sections not previously inspected. This process shall be repeated until, in the opinion of the Engineer, the supply duct system is acceptably clean

**END OF SECTION 23 31 13**

# SECTION 23 33 00 - DUCTWORK ACCESSORIES

## PART 1 - GENERAL

### 1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.

C. UL Compliance: Construct, test, and label fire dampers in accordance with UL Standard 555 "Fire Dampers and Ceiling Dampers" and U.L. Standard 555S "Motor-Driven Fire/Smoke Dampers."

D. NFPA Compliance: Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories.

E. SMACNA Compliance: All exhaust ducts comply with "Fire Damper and Heat Stop Guide".

F. All fire dampers, smoke dampers, fire/smoke dampers and radiation dampers shall meet the latest local building code requirements.

### 1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for each type of ductwork accessory, including dimensions, capacities, and materials of construction; and installation instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of ductwork accessory showing interfacing requirements with ductwork, method of fastening or support, and methods of assembly of components. Include details of construction equipment and accessories being provided.

C. Submittals for all damper types specified in this section shall include a schedule for each damper indicating net free area, actual face velocity and pressure drop (at sea level) based on net free area & the maximum air quantity which will be passing through the damper. Submittals without this information will be rejected.

D. Submit Heresite duct/equipment protective coating product data sheets and application instruction.

E. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of the LPS General Conditions of the Contract and Divisions through 25.

F. Maintenance Data: Submit manufacturer's maintenance data including parts lists for each type of duct accessory. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

## PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Dampers:

a. Greenheck
b. AWV
c. Air Balance, Inc.
d. Anemostat
e. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
f. Louvers & Dampers, Inc.
g. Penn Ventilator Co.
h. Pottoroff
i. Ruskin

2. Fire Dampers and Smoke Dampers:

a. Greenheck
b. Air Balance, Inc.
c. Phillips Industries, Inc. Conaire Division
d. Ruskin
e. Pottoroff

3. Turning Vanes:

a. Aero Dyne Co.
b. Airsan Corp.
c. Barb-Aire
d. Duro Dyne Corp.
e. Environmental Elements Corp.; Subs. Koppers Co., Inc.
f. Hart & Cooley Mfg. Co.

4. Duct Hardware:

a. Ventfabrics, Inc.
b. Young Regulator Co.
c. Duro-Dyne Corp.

5. Duct Access Doors:

a. Kess
b. Greenheck
c. Flexmaster
d. Cesco-Advanced Air
e. Duro Dyne Corp.
f. Ventfabrics, Inc.

6. Flexible Connections:

a. Duro Dyne Corp.
b. Ventfabrics, Inc.
c. General Rubber Corp. (Process & Exhaust Only)

7. Air Blenders:

a. Blender Products, Inc.

8. Constant Velocity Exhaust Fan Dampers:

a. American Warming and Ventilating

Note to specifier to use PVC or Heresite coating(s) for corrosive air stream and/or stainless steel (also for moisture laden airstream)

2.2 MANUAL VOLUME DAMPERS:

A. Low Pressure Rectangular Dampers (less than 2000 FPM and under 2" W.C. S.P. Differential):

1. For 12" in height or larger, use multiple opposed blade type and close fitted to ducts. The frame and blades shall be constructed of 16 ga. galvanized steel with plated steel shaft mounted with synthetic bearings. Linkage shall be in-jamb fixed type located outside the airstream made of plated steel tie bar and crank plates, with stainless steel pivots. Damper panels shall not exceed 48" wide. Provide jack shafting when duct size required is greater than 48" wide. Provide notched shaft end indicating damper position, locking quadrant to fix damper position and handle. Provide stand-off bracket for insulated ducts. For flat oval and round ductwork, provide type C housing.

2. For ducts less than 12" in height, frame shall be 18 ga. blade galvanized steel, steel axle with synthetic bearings locking quadrant handle and notched shaft end indicating damper position. Provide stand-off bracket for insulated ducts.

B. Low Pressure Round Dampers (less than 1800 FPM and under 1" W.C. S.P. differential):

1. For low pressure spin-in fitting dampers serving individual returns/diffusers, see 23 31 00.

2. Dampers 4" diameter through 18" diameter shall be 20 ga. galvanized steel frame and blade, utilize multi-blade square dampers with transitions for ducts over 18" diameter.

Axle shaft shall be plated steel with retainers mounted on synthetic bearings with notched end shaft indicating damper position, locking quadrant and handle. Provide stand-off brackets for insulated ducts.

a. Greenheck M80R-50 or approved equivalent.

C. Medium/High Pressure Rectangular Dampers (less than 4000 FPM and under 6" W.C. (48" wide or less) S.P. or 8" W.C. S.P. (36" wide or less)):

1. Dampers shall be opposed blade for volume control and parallel blade for isolation/shut-off service.

2. Frame shall be 16 ga. galvanized steel with welded corners or 1/8" thick 6063-T5 alloy aluminum frame. Blades shall be double skin galvanized steel with single-lock seam, or .081" thick 6060-T5 extruded aluminum, airfoil shape. Blade edge seals shall be vinyl, silicone, or other approved synthetic and metallic compression seals at the jambs.

Axles shall be hexagonal or square plated steel mounted on bronze oilite or synthetic (ACETAL) bearings. Linkage shall be in-jamb type located outside the airstream. Maximum damper size shall be 48" wide and 60" high. For isolation or shut-off duty, damper leakage shall not exceed 9.5 CFM/$Ft^2$ at 4" W.C. S.P. differential. Provide extended shaft with notched end indicating damper position, locking quadrant and handle. Provide stand-off brackets for insulated ducts.

D. Medium/High Pressure Round and Flat Oval Dampers (less than 3000 FPM and under 4" W.C. S.P. differential):

1. Damper frame construction shall be galvanized steel as follows:

| ROUND | |
|---|---|
| Under 6" dia. | 12 Gauge |
| 6" to 18" dia. | 14 Gauge |

| FLAT OVAL | |
|---|---|
| 6" to 12" wide | 2 x 1/2 x 14 gauge channel |
| 13" to 48" wide | 2 x 1/2 x 1/8 channel |

2. Damper blades shall be galvanized steel as follows:

| ROUND | |
|---|---|
| 4" to 18" diameter | 12 Gauge |

| FLAT OVAL | |
|---|---|
| 4" to 18" Wide | 12 Gauge |

3. Axles shall be 1/2" diameter plated steel up to 18" diameter and 18" wide flat oval, and 3/4" diameter plated steel over 18". Stainless sleeve bearings pressed in to the frame.

4. Provide notched end shaft to indicate damper position, locking quadrant and lever handle. Provide stand-off bracket for insulated duct.

Edit as required.

5. For isolation or shut-off service dampers shall be provided with edge seals with leakage rate not to exceed 7 CFM/ft$^2$ at 1" W.C. S.P. differential (based on 18" diameter).

E. Dampers in stainless steel duct shall be of equivalent construction to the above dampers, with all components made of stainless steel. Type 304 or 316 as specified for the ductwork.

F. Dampers in aluminum duct shall be of equivalent construction to the above dampers, with all components made of either aluminum or stainless steel.

Use control dampers below for special applications only. Do not use for typical commercial temperature control dampers. See Section 23 09 13.

2.3 CONTROL DAMPERS:

A. Dampers shall be opposed blade for volume control and parallel blade for isolation/shut-off service. Frame shall be 12 ga. galvanized steel with welded corners. Blades shall

be double skin galvanized steel with single-lock seam, airfoil shape with a strength greater than 14 ga.

AWV Model VC-422

B. Blade edge seals shall be double durometer vinyl and metallic compression seals at the jambs. Leakage shall not exceed 11.5 CFM/ft$^2$ at 4" W.C. S.P.

C. Axles shall be solid carbon steel mounted on bronze oilite bearings. Linkage shall be in-jamb type located outside the airstream.

D. Maximum damper size shall be 48" wide and 72" high.

Add or delete the following. Coordinate type of service to operate

E. For **isolation/and/automatic volume control dampers**, provide factory-supplied electric motor operators with quantities, voltage and sizes suitable for proper operation at the velocity and pressures the dampers will be operating at.

Verify specific manufacturer and model is capable of operating at specified operating pressure(s).

2.4 COUNTERBALANCED PRESSURE RELIEF DAMPERS:

A. For velocities less than 3000 FPM and under 2" W.C. S.P. differential provide dampers with parallel blades, counterbalanced and factory-set, field adjustable, to relieve at indicated static pressure. Construct blades of 16 ga. aluminum, provide 1/2" diameter ball bearings, 1/2" diameter steel axles spaced on 9" centers. Construct frame of 2" x 1/2" x 1/8" steel channel for face areas 25 sq. ft. and under; 4" x 1-1/4"" x 16 ga. channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up.

***Use the following for VFD Air Bypass***

B. For velocities above 3000 FPM and static pressure differential above 2" W.C.:

Provide dampers with parallel blades, counterbalanced and factory-set, field adjustable to start to open at indicated pressure. Construct blades of 16 gauge galvanized steel up to 32" length and 14 gauge over 32" length, 3/4" diameter plated steel axles, full length, re-lubricable ball bearings, heavy duty carbon steel linkage located out of airstream, 10 gauge galvanized steel frame silicone blade edge seals and silicone jamb seal, full flanges on both sides, mill finish with touch -up on welds and prime coat on black steel.

2.5 FIRE DAMPERS:

A. Fabricated Fire Dampers: Provide dampers constructed in accordance with SMACNA "Fire Damper and Heat Stop Guide."

B. Fire Dampers: Provide dynamic rated type B or C fire dampers except as noted on drawings. Construct sleeve of galvanized steel with bonded red acrylic enamel finish, gauge as required by the listing. All fire dampers shall be UL labeled. Provide fusible link rated at 160 to 165 deg. F (71 to 74 deg. C) unless otherwise indicated. See architectural

drawings for the separations and listings. Provide horizontal mounted fire damper with positive lock in closed position, and with the following additional features:

C. Damper Blade Assembly: Curtain Type.

D. Blade Material: Galvanized steel.

E. Provide integral sleeve type G fire dampers for sidewall air devices terminating at fire rated walls. Ruskin DIBD20-G or equivalent.

2.6 SMOKE DAMPERS:

A. Rectangular Motor-Driven Smoke Dampers: Frame constructed of 16-ga. steel, type 304 stainless steel side seals, silicone edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel formed interlocking blades, with factory mounted actuator motor, motor mounting bracket. Out of air stream plated steel linkage.

1. Ruskin Model SD-60 or approved equivalent.

Edit Note: Use 350°F for engineered smoke control systems.

B. Round Motor-Driven Smoke Dampers 18" and Under: Frame constructed of 20 gauge galvanized steel, 2 layers of galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers. Stainless steel sleeve bearings pressed into frame.

1. Ruskin SDR-25 or approved equivalent.

2. Use rectangular damper with smooth square/round transitions for dampers over 18" round.

C. Temperature Class 250°F/350°F.

D. Factory sleeve.

Edit Note: Select pneumatic actuator unless no pneumatic is available. Coordinate voltage.

E. Factory-mounted spring return actuator and 120v E/P valve. Actuator shall operate on 20 psi control air pressure. Factory-mounted 24V/120V spring return electric actuator.

F. Electric Damper Actuators:

1. Actuator shall have microprocessor based motor controller providing:
   a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   b. Shall be incapable of burning out if stalled before full rotation is reached.

2. Housing shall be steel and gears shall be permanently lubricated.

3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.

4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper. Actuators shall draw no more than .23A at 120V or 24V running,

or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.

5. Actuator shall carry a manufacturer's 5-year warranty and be manufactured under ISO9001 quality control

6. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).

G. Where indicated on drawings, or where required by the sequence of controls, provide factory mounted blade position switches to indicate fully open and fully closed.

H. Damper actuator shall fail open/closed upon loss of power/control air.

I. UL 555S & Class II.

## 2.7 COMBINATION FIRE/SMOKE DAMPERS:

A. Rectangular Fire/Smoke Dampers: 16 gauge galvanized steel frame, type 304 stainless steel side seals, combination silicone/galvanized steel edge seals, bronze oilite or stainless steel sleeve bearings, airfoil shaped galvanized steel parallel acting blades, square or horizontal plated steel axles, out of airstream in-jamb linkage with stainless steel pivots, factory sleeve, caulked and attached to damper in accordance with UL fire damper requirements.

1. Ruskin FSD-60 or approved equivalent.

2. Ruskin FSD-60V or approved equivalent where axles must be vertical.

B. Round Fire/Smoke Dampers 18" Diameter and Smaller: 20 gauge galvanized steel frame/integral sleeve, 2 layer galvanized steel butterfly blade equivalent to 14 gauge, silicone rubber seal sandwiched between blade layers, stainless steel sleeve bearings pressed into frame, retaining plates in accordance with the UL listing.

1. Ruskin FSDR-25 or approved equivalent.

2. Use rectangular damper with smooth square/round transitions for dampers over 18".

C. Paint sleeve with red enamel finish.

Edit Note: Use "D" for most jobs. Coordinate voltage. Edit out electric actuator when pneumatic is available.

D. Provide factory-mounted spring return actuator, 120V electro-pneumatic valve (to replace existing, only), 120V/24V electric actuator and electric heat-actuated manual-reset release device. The damper shall at all times be connected to the actuator. The damper closure shall be controlled to not less than 7 seconds and no more than 15 seconds. Release device shall be set at 165°F, unless otherwise noted. Replaceable, fusible elements are not acceptable. Actuator shall be suitable for 20 psi control air.

Edit Note: Use "E" only for projects requiring remote operation during fire conditions, such as an engineered smoke control system. Specify the reset panel and/or fire fighters control panel under either the Fire Alarm or Temperature Control Section. Coordinate with Electrical.

E. Provide factory-mounted spring return actuator, 120V electro-pneumatic valve (to replace existing, only), and an automatic reset thermal release device set to close the damper at

165°F/212°F. In addition, provide a second manual reset thermal release device set to close the damper when the duct temperature is above the damper's degradation temperature. Provide factory mounted and wired terminal strip to allow field connection of normal and override circuits. "Normal" circuit shall be through both thermal release devices, "override" circuit shall bypass first thermal release device but shall include second high limit device. The damper shall at all times be connected to the actuator. Damper closure shall be controlled to not less than 7 seconds and not more than 15 seconds. Replaceable fusible elements are not acceptable. Actuator shall be suitable for 20 psi control air.

Edit Note: Use "F" for budget-driven projects where control air is existing pneumatic controls will be maintained or where multiple dampers are controlled with a single E/P switch.

F. Provide factory-mounted spring return actuator, 120V electro-pneumatic valve (to replace existing, only, where shown on the drawings) and a fusible element in the pneumatic line. The fusible element shall vent the line, closing the damper, when the duct temperature exceeds 165 deg.

G. The damper closure shall be controlled to not less than 7 seconds and not more than 15 seconds. Pneumatic damper actuators, where allowed by LPS to replace existing, shall be suitable for 20 psi control air.

H. Electric Damper Actuators:

1. Actuator shall have microprocessor based motor controller providing:
   a. Electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   b. Shall be incapable of burning out if stalled before full rotation is reached.

2. Housing shall be steel and gears shall be permanently lubricated.

3. The actuators shall be direct coupled and employ a steel toothed clamp for connecting to damper shafts. Aluminum clamps or set-screw attachment are not acceptable.

4. Actuator shall have UL555S Listing by the damper manufacturer for a temperature equal to the damper.

5. Actuators shall draw no more than .23A at 120V or 24V running, or .1A holding at 120V or 24V (27 VA and 10 VA respectively for 24V power) for 70 in-# of torque.

6. Actuator shall carry a manufacturer's 5-year warranty and be manufactured under ISO 9001 quality control.

7. Damper actuators shall be Belimo Aircontrols FSLF (30 in-#) or FSNF (70 in-#).

I. Where indicated on the drawings or indicated in the sequence of control, provide factory mounted blade position switches to indicate fully open and fully closed.

J. Damper actuator shall fail close upon loss of power/control air.

K. 1 1/2 hour or 3 hour rating as required by construction type.

Edit Note: Use 350° for engineered smoke control systems.

L. UL 555, 555S, Class II, 250°F/350°.

M. Suitable for vertical or horizontal mounting.

N. Leakage not greater than 10 CFM per square foot at 1" W.C. pressure differential.

## 2.8 TURNING VANES:

A. Fabricated Turning Vanes: Provide fabricated 22 gauge, single blade or 24 gauge double bladed 4-1/2" radius, 3-1/4" spacing turning vanes and type 2, 4-1/2" wide runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards" Fig 2.3.

B. Turning vanes as a part of PVC coated air systems shall be PVC coated.

C. Do not use trailing edge turning vanes.

## 2.9 DUCT HARDWARE:

A. General: Provide duct hardware, manufactured by one manufacturer for all items on the project, for the following:

B. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.

C. Quadrant Locks: Provide for each manual volume damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

## 2.10 DUCT ACCESS DOORS:

A. Access Doors for Low Pressure Rectangular Duct: Construct of same or greater gauge as ductwork served, provide double wall insulated doors for insulated ductwork. Exposed insulation adhered to door is not acceptable. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. All access doors shall have gasket and will be air tight. Provide one side hinged, other side with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors. Where a hinged door cannot be fully opened a removable door may be used.

B. Access Doors for Medium and High Pressure Rectangular Duct: Insulated double wall round door and frame arranged for "Spin-In" installation, with continuous gasket in frame for door. Leakage of less than .5 cfm at 6" W.G.

Flexmaster "Inspector Series Spin Door" or equivalent.

C. Access Doors for Round Duct 20" and Less: Sandwich type door, constructed of an insulated double wall outer door connected to gasketed inner plate carriage bolts with hand knobs, and formed to fit the radius of the duct.

Ductmate "Sandwich" or equivalent.

D. Access Door for Round Duct Greater Than 20": 18" round insulated double wall access door in gasketed frame, attached to duct section similar to tee fitting.

E. Access Doors for Flat Oval Duct: Use door specified for medium and high pressure rectangular duct in flat portion, use door specified for round duct in curved portion.

Use the following for fume/exhaust systems.

F. All access doors in exhaust system shall have inside duct surface PVC coated or at the Contractor's option, Heresite coated as specified in this section.

2.11 FLEXIBLE CONNECTIONS:

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment. Shelf life shall be verified to not exceed six (6) months. Any sign of cracking on interior or exterior shall be cause for replacement immediately.

B. Use the following product types for each application accordingly:

1. Indoor Equipment Non-Corrosive Air Systems: Heavy glass fabric, double-coated with DuPont's NEOPRENE, non-combustible fabric, fire retardant coating with good resistance to abrasion and flexing. Fabric shall be 30 oz per square yard, capable of operating at -10$^{o}$F to 200$^{o}$F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventglas" Model as manufactured by VentFabric, Inc.

2. Outdoor Equipment Non-Corrosive Air Systems (exposed to weather and sun): Heavy glass fabric, double-coated with DuPont's HYPALON, non-combustible fabric, fire retardant coating with superb resistance to sunlight, ozone and weather which has documented 20-year-old exposure tests. Fabric shall be 26 oz per square yard, capable of operating at -10$^{o}$F to 250$^{o}$F, waterproof, air tight, 6 inches wide, complies with NFPA 90 and UL Standard #214. "Ventlon" Model as manufactured by VentFabrics, Inc.

3. High Temperature Non-Corrosive Air Systems: Heavy glass fabric coated with silicone rubber, non-combustible fabric, fire retardant coating, capable of operating and maintaining flexibility between temperatures of -25$^{o}$F to 500$^{o}$F. Fabric shall be 16 oz. per square yard, waterproof, air tight, 6 inches wide, complies with NFPA 90, UL Standard #214. "Ventsil" Model as manufactured by VentFabrics, Inc.

4. Indoor Corrosive Air System: Heavy glass fabric coated with DuPont teflon fluorocarbon resins, capable of operating between temperatures of - 20$^{o}$F and 500$^{o}$F. Fabric shall be 14 oz per square yard, watertight, air tight, chemically resistant to most chemicals including but not limited to sulfuric acid, acetic acid, chlorine, dimethyl ether, xylene, hexane, ozone, nitric acid, butyl acetate, ammonia gas and liquid, acetone, mercury, cyclohexane, methanol, 6 inches wide "Ventel" model as manufactured by VentFabrics, Inc.

5. Outdoor Corrosive Air Systems: Composite a 2-layer flexible duct connection using 1 layer Vent Fabrics Ventlon (sun-resistant) and 1 layer of VentFabrics Ventel (corrosion resistant), installing the Ventlon exposed to the weather and the Ventel exposed to air stream.

OR

***For high pressure or severe, special duty applications.***

6. For flanged fan connections provide round and/or rectangular as required, General Rubber Corporation, style 1092, carbon steel stainless steel back-up bars, 6" face to face, Neoprene elastomers, with UV resistant stabilizer, spark and corrosion resistant, suitable to 225 F. ±2 psi (±55.4" W.C.) pressure rating.

For larger than 60" round diameter provide slip over type General Rubber Corporation style 1087 with stainless steel screw clamp.

Consider use of multiple small blenders for better turndown for VAV systems. CAUTION: See page 12 Blender Products Catalog, Detail #2.

2.12 AIR BLENDERS:

A. Air blender(s) shall be of the type, size, pressure drop and capacity as scheduled and shown on the drawings.

B. All units shall be factory built and tested, and shall be installed in strict accordance with manufacturer's recommendations and as shown on drawings.

C. Fabrication shall be of .080 gauge aluminum, and all welded construction.

D. Units shall be completely fixed devices, with no moving parts, that shall be capable of providing mixed air temperature within +/- 6 degrees F. standard deviation from the theoretical mixed air temperature.

The following flow measuring station specification is based upon the Air Monitor fan mounted Vol-U- Probe and can be modified for duct mounted applications and is accurate to within 3% for more accurate requirements, use FAN-E and DAM1.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which ductwork accessories will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the Engineer.

3.2 INSTALLATION OF DUCTWORK ACCESSORIES:

A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.

B. Install turning vanes in square or rectangular 90 deg. elbows in supply, return and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

E. Provide duct access doors whether shown or not for inspection and cleaning upstream of all coils, fans, automatic dampers, fire dampers (minimum 16" x 24" in ducts larger than 18"), fire/smoke dampers, duct smoke detectors and elsewhere as indicated. Review locations prior to fabrication. Provide multiple access doors for large ductwork to provide adequate reach to equipment.

F. Install fire dampers and smoke dampers in accordance with manufacturers' instructions.

G. Provide fire dampers and smoke dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction.

H. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing.

I. Provide balancing dampers on high pressure systems where indicated. Use splitter dampers only where indicated on Drawings.

J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. Provide matching flanged backing frame with flexible connector where flanged fan connections are provided.

## 3.3 COORDINATION:

A. Coordinate with installers of other work to ensure that operators, reset devices, and fusible links are accessible at all fire, smoke, and fire/smoke dampers.

B. Show access space on coordination drawings. Locate over lay-in ceilings and above corridors wherever practical.

C. Order right/left/top/bottom arrangement as required to minimize field modifications.

## 3.4 FIELD QUALITY CONTROL:

A. Operate installed ductwork accessories after installation to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leak-proof performance.

B. After installation, test every fire and fire/smoke damper for proper operation and provide letter to Architect/Engineer certifying this work is complete and all dampers are functioning properly.

## 3.5 ADJUSTING AND CLEANING:

A. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

B. Label access doors in accordance with Division-15 section "Mechanical Identification".

C. Final positioning of manual dampers is specified in Division-15 section "Testing, Adjusting, and Balancing".

D. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

E. Touch up all scratches in PVC or Heresite coated surfaces with respective coating finish.

## 3.6 EXTRA STOCK:

A. Furnish extra fusible links to Owner, one link for every ten (10) installed of each temperature range; obtain receipt.

**END OF SECTION 23 33 00**

# SECTION 23 33 19 – DUCTWORK SOUND ATTENUATION

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Sound attenuators required by this section are indicated on drawings and schedules, and are not necessarily limited to this section.

B. Refer to other Division 23 sections for ductwork; external insulation of sound attenuators; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of sound attenuators with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. NFPA Compliance: Construct sound attenuators using acoustical fill complying with NFPA 90A, "Air Conditioning and Ventilating Systems."

2. ASTM Compliances: Comply with applicable requirements of ASTM E90 and E477.

3. AMCA 1011 CRP Compliance

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of sound attenuator furnished; schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

D. Maintenance Data: Submit maintenance data and parts list for each type of sound attenuator; including "trouble- shooting" maintenance guide. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver sound attenuators with identification on outside of casings indicating type of sound attenuator and location to be installed. Avoid crushing or bending, and prevent dirt and debris from entering and settling in sound attenuators.

B. Store sound attenuators so as to protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Cross Talk Silencers
   a. Aeroacoustic Corporation.
   b. Dynasonics
   c. Environmental Air Products
   d. Gale Noise Control; Division of Norwood Manufacturing Corp.
   e. Industrial Acoustics
   f. Koppers
   g. Semco
   h. Tempmaster Corp; Subs. of Temperature Industries Inc.
   i. Titus Products; Division of Philips Industries Inc.
   j. International Acoustics Company
   k. Rink

2. Duct Silencers
   a. Aeroacoustic Corporation.
   b. Gale Noise Control; Division of Norwood Manufacturing Corp.
   c. Semco
   d. International Acoustics Company
   e. Titus Products; Division of Philips Industries Inc.
   f. United Sheet Metal
   g. Rink

2.2 DUCT SILENCERS:

A. General: Provide factory-fabricated and tested duct silencers as indicated, selected with performance characteristics which match or exceed those indicated on schedule.

B. Casings: Construct of galvanized sheet metal/stainless steel with gauge and seam construction equal or greater than that recommended by SMACNA Duct Construction Standards for ductwork of same size and pressure class; but not less than 22-gauge for outer casing and 22-gauge for inner casing. All seams shall be lock formed and mastic filled.

C. Acoustic Fill: Provide inorganic mineral or glass fiber filler material, inert, vermin- and moisture-proof, of sufficient density to obtain specified acoustic performance. Pack under not less than 5% compression to eliminate voids due to vibration and settling.

D. Acoustic Performance: Provide silencer ratings that have been determined in duct at reverberative room test facility. Test silencer with air flow in both directions through silencer, in accordance with the latest version of ASTM E477, "Methods of Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance."

E. For acoustic ratings, include Dynamic Insertion Loss and Self-generated Noise Power Levels for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow at the design FPM face velocity.

F. Aerodynamic Performance: Provide silencers with static pressure loss equal to or less than that scheduled.

G. Certification: Provide certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance. Conduct all rating tests at same facility. Open testing facility for inspection by Architect/Engineer if requested.

H. For systems serving "clean" air flow (operating rooms or intensive care units or electronics manufacturing facilities), provide duct silencer rated for "clean flow" which is constructed non-erosive to eliminate carryover of organic particulate matter from the silencer, as well as non-generable to prevent adsorption of gases and particles into the fill. Acoustic infill shall be encapsulated with a polymer sheet material. The entire silencer shall meet NFPA 90 and 25/50 flame/smoke rating. Provide removable side to permit cleaning of concealed surface and replacement of fill.

2.3 CROSS TALK SILENCERS:

A. General: Provide factory-fabricated and tested cross talk silencers as indicated, selected with performance characteristics which match or exceed those indicated on schedule.

B. Construction: Construct outer casing of 22-gauge and interior baffles of 22-gauge galvanized steel. Lock form seams in outer casing. Provide glass fiber acoustical filler material, packed under compression. Construct so entire silencer is incombustible, moisture resistant, and imparts no odors to the ambient air.

C. Pressure Drop: Provide units that have equal or less pressure drop than that scheduled, and certify that static pressure has been measured by independent laboratory in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating Purposes".

D. Acoustical Characteristics: Provide units that have equal or greater noise reduction characteristics than those scheduled, and certify that noise reduction data has been measured by independent laboratory in accordance with ASTM E90, "Method for Laboratory Measurement of Airborne-Sound Transmission Loss of Building Partitions."

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which sound attenuators are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF SOUND ATTENUATORS:

A. General: Install sound attenuators as indicated, and in accordance with manufacturer's installation instructions.

B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

C. Duct Connections: Connect ductwork to sound attenuators in accordance with Division 23 ductwork sections.

3.3 FIELD QUALITY CONTROL:

A. Upon completion of installation and prior to initial operation, test and demonstrate that sound attenuators, and duct connections to sound attenuators, are leak tight.

B. Repair or replace sound attenuators and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.4 CLEANING:

A. Clean exposed factory finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

**END OF SECTION 23 33 19**

# SECTION 23 34 00 - AIR HANDLING FANS

PART 1 - GENERAL:

1.1 DESCRIPTION OF WORK:

A. Extent of air handling equipment work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Divisions 20 through 25 sections for vibration control; control system; sequence of operation; testing, adjusting and balancing.

C. Refer to Division 26 for the following work; not work of this section.

1. Power supply wiring from power source to power connections at air handling units.

D. Refer to Section 23 05 13 Paragraph 2.6 for requirements of sheaves and belts for critical areas.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air handling equipment of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:

1. Fans Performance Ratings: Establish flow rate, pressure, power air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

2. UL Compliance: Provide air handling equipment which are listed by UL and have UL label affixed.

3. UL Compliance: Provide air handling equipment which are designed, manufactured and tested in accordance with UL 805 "Power Ventilators".

4. NEMA Compliance: Provide motors and electrical accessories complying with NEMA standards.

5. Sound Power Level Ratings: Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings from laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating."

6. Nationally Recognized Testing Laboratory and NEMA Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be defined in OSHA Regulation 1910.7.

7. Electrical Component Standards: Components and installation shall comply with NFPA 70 "National Electrical Code."

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical data for air handling equipment including specifications, capacity ratings, dimensions, weights, materials, operating & service/access clearance accessories furnished, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, methods of assembly of components, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air-handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are manufacturer-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.5 SEQUENCING AND SCHEDULING:

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

B. Coordinate the installation of roof curbs, equipment supports, and roof penetrations.

C. Coordinate the size and location of structural steel support members.

1.6 EXTRA MATERIALS:

A. Furnish one additional complete set of belts for each belt-driven

fan. PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Centrifugal Fans:
   a. Aladdin Heating Corp.
   b. Buffalo Forge Co.
   c. ILG Industries, Inc.
   d. Loren Cook Co.
   e. New York Blower Co.
   f. Trane Co.
   g. Twin City Fan and Blower Co.
   h. Greenheck
   i. York; Division of York International

j. Carnes

2. Utility Sets:
   a. Acme Engineering And Mfg. Corp.
   b. Aladdin Heating Corp.
   c. Buffalo
   d. Brundage (The) Co.
   e. Loren Cook Co.
   f. ILG Industries, Inc.
   g. New York Blower Co.
   h. Penn Ventilator Co., Inc.
   i. Trane Co.
   j. Twin City Fan and Blower Co.
   k. Greenheck

3. Tubular Centrifugal Fans:
   a. Acme Engineering and Manufacturing Corp.
   b. Aladdin Heating Corp.
   c. Buffalo
   d. Loren Cook Co.
   e. New York Blower Co.
   f. Twin City Fan and Blower Co.
   g. Greenheck
   h. Carnes

4. Inline Centrifugal Fans:
   a. Acme Engineering and Manufacturing Corp.
   b. Buffalo
   c. Loren Cook Co.
   d. Penn Ventilator Co.
   e. Jenn Industries Inc.
   f. New York Blower Co.
   g. Greenheck
   h. Carnes
   i. Twin City Fan and Blower Co.

5. Centrifugal Roof Ventilators:
   a. Acme Engineering and Manufacturing Corp.
   b. Aerovent, Inc.
   c. Briedert Co., C.G.
   d. Carnes Company, Inc.
   e. Loren Cook Co.
   f. Jenn Industries, Inc.
   g. Penn Ventilator Co., Inc.
   h. Greenheck
   i. Twin City Fan and Blower Co.

6. Centrifugal Plug Fans:
   a. Peerless Fan Co.
   b. Chicago Blower
   c. Greenheck
   d. Twin City Fan and Blower Co.
   e. New York Blower
   f. Carnes

7. Axial Roof Ventilators:
   a. Acme Engineering & Mfg. Corp.

b. Aerovent, Inc.
c. Carnes Company, Inc.
d. Loren Cook Co.
e. Jenn Industries, Inc.
f. Penn Ventilator Co., Inc.
g. Greenheck

8. Upblast Propeller Roof Exhaust Fans:
   a. Loren Cook Co.
   b. Essick Air Products, Breidert.
   c. Greenheck
   d. ILG Industries, Inc.
   e. Carnes
   f. Twin City Fan and Blower Co.

9. Centrifugal Wall Ventilators:
   a. Acme Engineering & Mfg. Corp.
   b. Briedert Co., C.G.
   c. Carnes Company, Inc.
   d. Greenheck
   e. ILG Industries, Inc.
   f. Jenn Industries, Inc.
   g. Penn Ventilator Co., Inc.
   h. Twin City Fan and Blower Co.

10. Ceiling-Mounted Ventilators:
   a. Acme Engineering & Mfg. Corp.
   b. Bridert Co., C.G.
   c. Broan Mfg. Co., Inc.
   d. Carnes Company, Inc.
   e. Loren Cook Co.
   f. Greenheck
   g. ILG Industries, Inc.
   h. Jenn Industries, Inc.
   i. Penn Ventilator Co., Inc.
   j. Thermador/Waste King; Div. of Norris Industries.
   k. Twin City Fan and Blower Co.

11. Propeller Fans:
   a. Acme Engineering & Mfg. Corp.
   b. Aerovent Inc.
   c. Briedert Co., C.G.
   d. Carnes Company, Inc.
   e. Loren Cook Co.
   f. ILG Industries, Inc.
   g. Jenn Industries, Inc.
   h. New York Blower Co.
   i. Penn Ventilator Co., Inc.
   j. Greenheck
   k. Carnes
   l. Twin City Fan and Blower Co.

12. Vane-axial Fans:
   a. Acme Engineering & Mfg. Corp.
   b. Aerovent, Inc.
   c. ILG Industries
   d. New York Blower Co.

e. Trane Co.
f. Twin City Fan and Blower Co.
g. Flakt
h. Greenheck
i. Carnes
j. Twin City Fan and Blower Co.

13. Variable Pitch Vane-axial Fans
    a. Joy Mfg. Co.
    b. Trane Co.
    c. Flakt
    d. Greenheck
    e. Carnes
    f. Twin City Fan and Blower Co.

14. Bathroom Exhausters
    a. Broan Mfg. Co., Inc.
    b. NuTone Div; Scovell Mfg. Co.
    c. Thermador/Waste King; Div. of Norris Industries.
    d. Greenheck
    e. Twin City Fan and Blower Co.

15. Gravity Ventilator (Hooded and Round Stationary)
    a. Penn Ventilator Co., Inc.
    b. Briedert Co., C.G.
    c. Bristol Fiberlite Industries
    d. Burt Mfg. Co.
    e. Hirschman-Pohle Co.
    f. Robertson Co., H.H.
    g. Steelite, Inc.
    h. Greenheck
    i. Twin City Fan and Blower Co.

16. Low Silhouette Box-Type Gravity Ventilators
    a. Robertson Co., H.H.
    b. Swartwout Industries, Inc.
    c. Greenheck
    d. Twin City Fan and Blower Co.

17. Prefabricated Roof Curbs
    a. Custon Curb, Inc.
    b. Pate Co.
    c. S & L Manufacturing Co.
    d. ThyCurb Div.; Thybar Corp.
    e. Twin City Fan and Blower Co.

## 2.2 FANS, GENERAL:

A. General: Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.

C. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor: 1.4.

D. Belts: Oil-resistant, nonsparking, and nonstatic.

E. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions. Provide energy efficient motor.

1. Belt Guards: Provide steel belt guards for motors mounted on the outside of the fan cabinet.

NOTE: Light duty/8 hours/day operation, 20,000 to 60,000 medium duty/8 to 16 hours/day operation, 60,000 to 100,000 and heavy duty/24 hours/day operation 100,000 to 200,000.

F. Shaft Bearings: Provide type indicated, having a median life "Rating Life" AFBMA L10 of [ ] calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.

G. Factory Finish: The following finishes are required:

1. Sheet Metal Parts: Prime coating prior to final assembly.

2. Exterior Surfaces: Baked-enamel finish coat after assembly.

H. Vibration: Provide vibration isolators as specified in Section 23 05 48 and as indicated.

EDIT NOTE: Provide the following section for projects utilizing a vibration consultant, if so directed. Consider limiting types and/or horsepower of fans.

## 2.3 FAN VIBRATIONAL PERFORMANCE REQUIREMENTS:

A. The fan manufacturer shall provide all fans over 5000 cfm according to the following specifications and provide submittals as noted.

1. Rotor shafts shall be solid steel. Hollow shafts are not permitted.

2. The design resonant speed of the fan system shall be a minimum of 25 percent above the fan maximum operating speed considering both wheel mass and inertia. The design resonant speed is that speed which corresponds to the natural frequency of the spring-mass system consisting of the rotating components, bearing lubrication and housing and supporting pedestal with the supporting floor, foundation, etc., considered to be infinitely rigid.

3. Design resonant calculations shall be submitted by the Manufacturer to support the design resonant speed value to insure that the bearing support structure has adequate stiffness in all three directions (lateral, axial and vertical). Use of vibration isolation springs is not allowed.

4. Shop drawings shall be submitted for fan assembly details including dimensions and thickness of steel frames and bases, rotor shaft dimensions, wheel weight, bearing types and center-to-center distance. The Manufacturer shall not withhold this information for proprietary or any other reasons.

5. The fan shall be factory balanced so that the inboard and outboard bearing motions do not exceed 1 mil peak-to-peak in any direction when measured in the "filter in" measurement mode at any operating speed. On-site fan balancing will be required if the operational bearing motions (inboard and outboard) exceed 1.2 mils, peak-to-peak in any direction when measured in the "filter out" mode at any operating speed. The vibrating measurement system used, in either case, must have a flat response down to 120 rpm.

6. The Manufacturer shall provide a written vibration balance report of the fan showing the vibrations as described above. The report shall include a description of how the fan was mounted during the test, operating conditions which include rpm, static pressure and duct arrangements and the type of vibration instruments used.

B. The fan and air handler support structures are an integral part of the vibratory system and shop drawings are required. It is essential for those structures to be capable of providing a direct avenue for transfer of forces generated by the fans and motors to the supporting structural floor system.

C. If the Manufacturer cannot provide design resonant calculations, then the Owner will, at their expense of the contractor, employ a Structural Vibration Consultant to perform design resonant calculations based upon the shop drawings. The results of the analysis may require structural changes to the fan support system. The Manufacturer shall make these changes without cost to the owner or choose to assemble the fan and perform a vibration test to demonstrate compliance with the peak-to-peak limits.

D. The Owner will employ, at their expense, a Structural Vibration Consultant to measure the vibrations after start-up should the fan system)s) fail the vibration tests, the contractor will be required to pay for subsequent tests of the vibration after repairs are made.

E. Fan vibrations which exceed the amounts, as described above, during operation in the warranty period shall be reduced by the Contractor. The Contractor can choose to dynamically balance the fan in place using a recognized specialist, replace bearings or make structural modifications to reduce the vibrations.

F. The Owner will provide and install a sticker identifying the fan maximum operating speed. Speed changes which exceed this value are not permitted without permission of Structural Vibration Consultant through the University Representative.

## 2.4 CENTRIFUGAL FANS:

A. General Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

B. Housings: Fabricated from formed and reinforced galvanized steel panels to form curved scroll housings with continuously welded or deep-locked seams and access doors or panels to allow access to internal parts and components.

1. Inlet Cones: Spun metal.

2. Duct Connections: Flanged.

3. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

C. Fan Wheels: Single-width, single-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.

D. Fan Wheels: Double-width, double-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.

1. Blade Materials: Steel.

2. Blade Type: Backward-curved, flat-plate type.

3. Blade Type: Backward-curved, airfoil type.

4. Blade Type: Forward-curved, airfoil type.

E. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow- block type ball bearings.

OR

Shaft Bearings: Grease-lubricated, self-aligning, pillow-block type; tapered roller bearings with double-locking collars and two- piece, cast-iron housing.

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Shaft Bearings: Grease-lubricated, self-aligning, pillow-block type, with double spherical roller bearings with adapter mount and two-piece cast-iron housing.

F. Accessories: The following accessories are required.

1. Scroll Bypass Dampers: Aluminum, opposed, airfoil blades with extruded vinyl seals on blades, low-friction bearings, and positive control linkage for manual or automatic operation.

2. Scroll Housing Access Doors: Latch-type handles; flush-mounted for uninsulated housings and raised-mounted for insulated housings.

3. Inlet Vanes: Radial vanes with linkage for manual or automatic operation.

4. Double-Width Fans Inlet Vanes: Connected for single operator.

5. Inlet Screens: Heavy wire mesh screens, mounted inside of shaft bearings.

6. Discharge Dampers: Heavy-gauge steel, opposed blade design, with linkage for manual or automatic operation.

7. Drain Connections: Threaded, 3/4-inch NPS, capped nipple installed at lowest point of housing.

8. Shaft Cooler: Metal disc between bearings and fan wheel, designed to dissipate heat from shaft.

9. Spark-Resistant Construction: AMCA construction option A, B, or C as indicated.

10. Shaft Seals: Air-tight seals installed around shaft on drive side of single-width fans.

11. Special Coatings: Provide protective coatings on fans as indicated.

12. Extended Grease Lines: Extend grease lines from bearings to a convenient, visible location and terminate with grease fitting.

## 2.5 UTILITY SET FANS:

A. General Description: Belt-driven, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Housings: Fabricated from heavy-gauge steel with side sheets fastened to scroll sheets by means of welding or deep lock seam.

1. Inlet: Round duct collar.

2. Discharge: Slip-joint duct connection.

3. Housings Discharge Arrangement: Adjustable to 8 standard positions.

C. Fan Wheels: Single-width, single-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.

1. Blade Materials: Steel.

2. Blade Type: Backward-curved, die-formed.

3. Blade Type: Forward-curved, die-formed.

D. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow- block-type ball bearings.

E. Accessories: The following accessories are required where indicated:

1. Backdraft Dampers: Gravity-actuated with counterweight and interlocking aluminum blades and felt edges in steel frame installed on fan discharge.

2. Access Doors: Gasketed doors with latch-type handles.

3. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.

4. Spark-Resistant Construction: AMCA construction option A, B, or C as indicated.

5. Inlet Screens: Removable, heavy wire mesh.

6. Drain Connections: 3/4-inch, threaded coupling drain connection installed at lowest point of housing.

7. Weather Hoods: Weather-resistant with stamped vents over motor and drive compartment.

8. Special Coatings: Provide protective coatings on fans as indicated.

## 2.6 TUBULAR CENTRIFUGAL FANS:

A. General Description: Tubular, inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets and accessories.

B. Housings: Fabricated from formed and reinforced galvanized steel panels with welded seams.

1. Duct Connections: Spun inlet cones with flange removable for access to internal parts, and an outlet flange.

2. Mounting Brackets: Suitable for horizontal or vertical mounting.

3. Motor Mount: Adjustable for belt tensioning.

4. Fan Wheels: Single-width, single-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.
   a. Blade Materials: Steel.
   b. Blade Type: Backward-curved, flat-plate type.
   c. Blade Type: Backward-curved, airfoil type.

C. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow- block-type ball bearings.

OR

D. Shaft Bearings: Grease-lubricated, self-aligning, pillow-block type; tapered roller bearings with double-locking collars and two- piece, cast-iron housing.

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E. Shaft Bearings: Grease-lubricated, self-aligning, pillow-block type, with double spherical roller bearings with adapter mount and two-piece cast-iron housing.

F. Accessories: The following accessories are required where indicated:

1. Companion Flanges: For inlet and outlet connections.

2. Weather Cover: Heavy-gauge, galvanized, sheet steel with ventilation slots, bolted to housing.

3. Belt Guard: Manufacturer's standard to meet OSHA requirements.

4. Ceiling Brackets: Structural angles welded and drilled for hanger rod attachment.

5. Inlet Vanes: Radial vanes with linkage suitable for manual or automatic operation.

6. Access Doors: Located over wheel in an accessible position, hinged and having latch-type handles; flush mounted for uninsulated housings, raised-mounted for insulated housings.

7. Spark-Resistant Construction: AMCA construction option A, B, or C as indicated.

8. Inlet and Outlet Screens: Removable, heavy wire mesh.

9. Special Coatings: Provide protective coatings on fans as indicated.

10. Drain Connections: Provide 3/4" threaded coupling drain connection at lowest point of housing.

## 2.7 INLINE CENTRIFUGAL FANS:

A. General Description: Inline, belt-driven, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets, and accessories.

B. Housing: Split, spun-aluminum housing, with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

D. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Wheel: Aluminum, airfoil blades welded to aluminum hub.

F. Bearings: Grease lubricated ball or roller anti-friction type with extended lubrication lines to outside fan housing.

G. Accessories: The following accessories are required as indicated:

1. Volume Control Damper: Manual operated with quadrant lock, located in fan outlet.

2. Companion Flanges: For inlet and outlet duct connections.

3. Fan Guards: Expanded metal in removable frame.

4. Speed Control: Variable speed switch with on-off control and speed control for 100 to 50 percent of fan air delivery.

## 2.8 CENTRIFUGAL ROOF VENTILATORS:

A. General Description: Belt-driven or direct-drive as indicated, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base and accessories.

B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base with venturi inlet cone.

1. Up-blast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.

4. Fan and motor isolated from exhaust air stream.

E. Accessories: The following items are required as indicated:

1. Disconnect Switch: Non-fusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.

2. Bird Screens: Removable 1/2-inch mesh, 16-gauge, aluminum or brass wire.

3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.

OR

Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.
a. Blades: Die-formed sheet aluminum.
b. Frame: Extruded aluminum, with waterproof, felt blade seals.
c. Linkage: Nonferrous metals, connecting blades to counter weight or operator.
d. Operators: Manufacturer's standard electric motor.

OR

Operators: Manufacturer's standard motor (pneumatic to replace existing, only).

4. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch thick, rigid, fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof decks; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
a. Overall Height: 12 inches.

*** EDIT NOTE: Select Unhoused or Housed Fan***

2.9 CENTRIFUGAL PLUG FAN:

A. Provide unhoused/housed fan assembly complete with motor, non-overloading centrifugal fan wheel, flanged mounting panel, screw-type motor adjustment.

B. Belt guard shall be provided at fan motor and belt to meet OSHA requirements.

C. Construction of fan shall be completely welded.

D. Fan shall be painted with enamel paint.

E. Ceramic felt seal element between fan panel and metal retaining disc.

F. Shaft Bearings: Grease-lubricated, self-aligning pillow-block type; tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

G. Fan Wheel: Single width, single-inlet, welded to cast-iron or cast-steel hub and spun steel inlet cone, with hub keyed to the shaft.

H. Accessories: The following accessories are required where indicated.

1. Inlet vanes: Radial vanes with linkage for automatic operation.

2. Shaft Seals: Air tight seals installed around shaft on drive side of single-width fans.

2.10 AXIAL ROOF VENTILATORS:

A. General Description: Belt-driven or direct-drive as indicated, axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base and accessories.

B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; and square, one-piece, hinged, aluminum base.

C. Fan Wheel: Aluminum hub and blades.

D. Fan Wheel: Steel hub and blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.

F. Accessories: The following items are required as indicated:

1. Disconnect Switch: Non-fusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, 16-gauge aluminum or brass wire.

3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base, factory set to close when fan stops.

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Dampers: Motor-operated, parallel-blade, volume control dampers mounted in curb base.
a. Blades: Die-formed sheet aluminum.
b. Frame: Extruded aluminum, with waterproof, felt blade bumpers.
c. Linkage: Nonferrous metals.
d. Operators: Manufacturer's standard electric motor.

O
R

Operators: Manufacturer's standard motor (pneumatic to replace existing, only).

4. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch thick, rigid fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof deck; and 2-inch wood nailer. Size as required to suit roof opening and fan base.
a. Overall Height: 12 inches.

## 2.11 UPBLAST PROPELLER ROOF EXHAUST FANS:

A. General Description: Belt-driven or direct-drive as indicated, propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base and accessories.

B. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel, containing galvanized steel butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

O
R

Wind Band, Fan Housing, and Base: Reinforced and braced aluminum, containing aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

1. Dampers Rods: Steel with bronze bearings.

OR

Dampers Rods: Steel with nylon bearings.

C. Fan Wheel: Dynamically and statically balanced, replaceable, cast- aluminum blades fastened to cast-aluminum hub. Factory-set pitch angle of blades.

O
R

Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.

D. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow- block-type ball bearings.

E. Motors and Fan Wheel Pulleys: Adjustable pitch. Select pulley so that pitch adjustment is at the middle of the adjustment range at design conditions.

F. Motors Mounts: Outside of the fan cabinet with adjustable base for belt tensioning, drive assembly and belts enclosure, and weatherproof housing of same material as fan housing.

G. Roof Curbs: Prefabricated, heavy-gauge, galvanized steel; mitered and welded corners; 2-inch thick, rigid fiberglass insulation adhered to inside walls; built-in cant and mounting flange for flat roof deck; and 2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Overall Height: 12 inches.

## 2.12 CENTRIFUGAL WALL VENTILATORS:

A. General Description: Belt-driven or direct-drive as indicated, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly and accessories.

B. Housing: Heavy-gauge, removable, spun-aluminum, dome top and outlet baffle; venturi design fan inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.

4. Fan and motor isolated from exhaust air stream.

E. Bearings: Permanently lubricated, permanently sealed anti-friction ball bearings.

F. Accessories: The following items are required as indicated:

1. Disconnect Switch: Non-fusible type, with thermal overload protection mounted inside fan housing, factory-wired through an internal aluminum conduit.

2. Bird Screens: Removable, 1/2-inch mesh, 16-gauge aluminum or brass wire.

3. Dampers: Counterbalanced, parallel-blade backdraft dampers mounted in curb base, factory set to close when fan stops.

OR

Dampers: Motor-operated, parallel-blade dampers mounted in curb base.
a. Blades: Die-formed sheet aluminum.
b. Frame: Extruded aluminum, with waterproof, felt blade bumpers.
c. Linkage: Nonferrous metals.
d. Operators: Manufacturer's standard electric motor.

OR

Operators: Manufacturer's standard motor (pneumatic to replace existing, only).

## 2.13 CEILING-MOUNTED VENTILATORS:

A. General Description: Centrifugal fan designed for installation in ceiling, wall, or concealed inline applications.

B. Housing: Galvanized steel lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: Stainless steel, louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Remote Fan Speed Control: Solid state, capable of controlling fan speed from full speed to approximately half speed.

G. Accessories: Manufacturer's standard roof jack, wall cap, and transition fittings as indicated.

## 2.14 PROPELLER FANS:

A. General Description: Belt-driven or direct-drive propeller fans as indicated consisting of fan blades, hub, housing, orifice ring, motor, drive, and accessories.

B. Housings: Galvanized, sheet steel with flanged edges, and integral orifice ring.

C. Wheels: Formed-steel blades riveted to a heavy-gauge steel spider bolted to cast-iron

hub. OR

Fan Wheel: Replaceable, cast-aluminum blades fastened to cast- aluminum hub. Factory set pitch angle of blades.

OR

Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub. Factory set pitch angle of blades.

D. Drive Assembly: Direct-drive or belt-driven as indicated.

E. Belt-Driven Drive Assembly: Resiliently mounted to the housing, with the following features:

1. Pulleys: Cast-iron, adjustable-pitch.

2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3. Fan Shaft: Turned, ground, and polished steel drive shaft keyed to wheel hub.

4. Motor and Drive Assembly: Resiliently mounted to the housing.

F. Accessories: The following accessories are required as indicated:

1. Belt Guards: Expanded metal with reinforced edges.

2. Gravity Shutters: Gravity-type shutters with aluminum blades in steel frames, mounted on discharge side of fan.

## 2.15 VANEAXIAL FANS:

A. General Description: Belt-driven or direct-drive as indicated, variable pitch or adjustable pitch as indicated, vane-axial fans consisting of fan wheel and housing, straightening vane section, factory-mounted motor, an inlet cone section, and accessories.

1. Variable pitch fans include internally-mounted actuator, externally mounted positive positioner and mechanical-blade-pitch indicator for variable volume operation.

B. Housings: Steel housing, 14-gauge minimum, with inlet bell and diffuser sections.

1. Inlet and Outlet Connections: Outer mounting frame and companion flanges; inlet cone shall be welded to the fan raceway.

2. Guide Vane Section: Integral guide vanes downstream of the fan wheel designed to straighten the airflow.

C. Wheels: Cast-aluminum, axial-flow type, with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid steel key.

1. Variable-Pitch Fans: Provide a factory-mounted actuator and blade pitch operating mechanism.

D. Fan Hub and Blade Bearing Assemblies: Cast aluminum, machined and fitted with threaded bearing wells to receive blade bearing assemblies.

1. Blades: Replaceable, cast aluminum; factory-mounted and balanced to hub assembly.

2. Fan Shaft: Turned, ground, and polished steel.

3. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings.

OR

Shaft Bearings: Grease-lubricated, self-aligning, pillow-block type; tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

E. Direct-Drive Units: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

F. Belt-Drive Units: Provide enclosure around belts and sheaves.

G. Motor Mounting: Adjustable base.

1. Sheaves: Adjustable.

2. Belts: Oil-resistant, non-sparking, and non-static.

3. Accessories: The following accessories are required as indicated:

H. Companion Flanges: Rolled-steel flanges.

1. Inlet and Outlet Screens: Heavy wire mesh inlet screens on fans not connected to ductwork.

2. Backdraft Dampers: Butterfly-style, for mounting with flexible connection to discharge of the fan, or direct-mounted to the discharge diffuser section.

3. Stall Alarm Probe: A sensing probe capable of detecting fan operation in stall and sending a signal to control devices. Control devices and sequence of operation are specified in other Divisions 20 through 25 sections.

4. Flow Measurement Port: Pressure measurement taps installed in the inlet of the fan to detect and signal air flow readings to temperature control systems. Control devices and sequence of operation are specified in other Divisions 20 through 25 sections.

5. Inlet Vanes: Adjustable; having peripheral control linkage operated from outside of the air stream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation as indicated.

## 2.16 CABINET FANS:

A. Casing shall be fabricated of heavy gauge galvanized or painted steel and shall be fully insulated. Panels shall be removable for complete access to the unit interior.

B. Fan wheel bearings shall be selected for a minimum average life of 200,000 hours.

C. Fan motor shall be mounted on a universal motor base, with adjustable belt drive and belt guard.

D. Provide vibration isolators.

## 2.17 AIR INTAKE AND RELIEF HOOD:

Show installed height above roof to bottom of hood on drawings. Roof curb height must meet building code requirements.

A. Roof intake and relief hood housing shall be constructed of heavy gauge aluminum and shall be fully weatherproof.

B. Roof intake and relief hood shall be complete with [louvered sides] [insulated top] [hinged top] [hinged side section] [bird screen,] [gravity backdraft damper,] [exhaust cap], [counterbalanced relief damper] [relief cap], [and roof curb].

The following requires very careful editing for each specific project.

2.18 KITCHEN VENTILATION SYSTEM:

A. Kitchen Exhaust Hood:

1. Hood shall be grease extraction type exhaust hood with integral make-up air system. Hood shall be all-welded 18 gauge stainless steel/painted black steel construction including stainless steel grease extractors, trough, and receptacle, adjustable supply air grilles, vapor-proof incandescent lights, and factory installed/field installed dry chemical fire extinguishing system.

2. Extinguishing system shall include wall mounted manual pull station, control cabinet, and chemical canisters. All dry chemical piping shall be galvanized steel, schedule 40, ASTM A-120. All exposed piping shall be installed within chrome plated sleeves.

3. Mechanical gas safety shut-off valve with manual reset shall be furnished by the hood manufacturer and installed by the plumbing contractor.

4. Hood shall be designed and constructed in complete accordance with bulletin NFPA-96.

B. Kitchen Hood Make-up Air Unit:

1. Make-up air unit shall be packaged roof mounted combination supply and exhaust air unit complete with 16 gauge steel casing with weatherproof baked enamel finish, individual centrifugal supply and exhaust fans and motors, separated supply and exhaust section, adjustable belt drives, 2"thick intake filters, intake and discharge hoods with bird screens, supply fan discharge damper, 18 gauge galvanized steel roof curb.

C. Kitchen exhaust hood and make-up air unit shall be compatible for supply and exhaust directly to and from the installation, in complete accordance with the requirements of bulletin NFPA 96.

D. Kitchen exhaust hood manufacturer shall supervise the installation and air balance of the hood and shall guarantee full performance of the exhaust hood under all conditions without smoke blowout or cold air discharge into the occupied space. Hood and installation shall meet all State and local Health Department requirements and shall be fully approved by all agencies having jurisdiction, including the local fire department.

E. Shop drawings shall include extinguisher piping installation drawings showing number of heads and location, pipe sizes, number of canisters and total charge.

2.19 AUTOMOTIVE EXHAUST SYSTEM:

A. Overhead:

1. System shall be overhead hanging type and shall be installed in complete accordance with the manufacturer's recommendations.

2. Exhaust hoses shall be no-crush neoprene, sizes as noted on drawings. Hose assembly shall include tailpipe adaptor(s), bumper hood, nylon cord and pulley set with cleats.

3. Overhead ductwork shall be as specified in Section 23 31 13.

B. Underfloor:

1. System shall be underfloor disappearing type and shall be installed in complete accordance with manufacturer's recommendations.

2. Floor outlets shall be heavy cast aluminum dual/single type with hinged doors. Assembly shall include sweep connection and saddle for connection to transite underfloor duct. Doors shall close automatically and shall be replaceable.

3. Exhaust hoses shall be flexible stainless steel, size as noted on drawings. Hose assembly shall include insertion guide, bumper hook and tailpiece adaptor.

4. The underfloor duct systems shall be transite/[ ] as specified in Section 23 31 13.

C. Exhaust Fan:

1. Exhaust fan shall be as specified under Utility Fan and shall include corrosion-resistant coating on all parts within the airstream, and non-overloading backward inclined blades. Fan construction shall be AMCA type B non-sparking construction.

| Specify any special features of construction for the exhaust fans in the Exhaust Fan Schedule on drawing. |
|---|

2.20 PREFABRICATED ROOF CURBS:

A. Furnish and install roof curbs as scheduled for duct openings through the roof and for exhaust fan support. The curbs shall be galvanized steel self-flashing type/with integral cant, for flashing in the field. If the curbs are to have sound attenuation qualities, they shall be not less than those catalogued for the equipment specified.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fans.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL:

A. Install fans level and plumb, in accordance with manufacturer's written instructions. Support units using vibration control devices as indicated. Vibration control devices are specified in Section 23 05 48 "Vibration Control."

1. Support floor-mounted units on concrete equipment bases using neoprene pads. Secure units to anchor bolts installed in concrete equipment base.

OR

Support floor-mounted units on concrete equipment bases using housed spring isolators. Secure units to anchor bolts installed in concrete equipment base.

2. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
   a. Installation of roof curbs is specified in Division 7.

3. Suspended Units: Suspend units from structural steel support frame using threaded steel rods and vibration isolation springs.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

## 3.3 EQUIPMENT BASES:

A. Construct concrete equipment pads as follows:

1. Coordinate size of equipment bases with actual unit sizes provided. Construct base 4 inches larger in both directions than the overall dimensions of the supported unit.

2. Form concrete pads with steel channels conforming to ASTM A 36, size and location as indicated. Miter and weld corner and provide cross bracing. Anchor or key to floor slab.

3. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.

4. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.

5. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C150, 4000 psi compressive strength and normal weight aggregate.

6. Clean exposed steel form in accordance with SSPC Surface Preparation Specifications SP 2 or SP 3, and apply 2 coats of rust-preventive metal primer.

## 3.4 CONNECTIONS:

A. Duct installations and connections are specified in other Divisions 20 through 25 sections. Make final duct connections on inlet and outlet duct connections with flexible connections.

B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Ensure that rotation is in

direction indicated and intended for proper performance. Do not proceed with centrifugal fan start-up until wiring installation is acceptable to centrifugal fan Installer.

2. Temperature control wiring and interlock wiring are specified in Divisions 20 through 25.

3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.

## 3.5 FIELD QUALITY CONTROL:

A. Upon completion of installation of air handling equipment, and after motor has been energized with normal power source, test equipment to demonstrate compliance with requirements. Where possible, field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

B. Manufacturer's Field Inspection: Arrange and pay for a factory-authorized service representative to perform the following:

1. Inspect the field assembly of components and installation of fans including ductwork and electrical connections.

2. Prepare a written report on findings and recommended corrective actions.

## 3.6 ADJUSTING, CLEANING, AND PROTECTING:

A. Startup, test and adjust air handling equipment in presence of manufacturer's authorized representative.

B. Adjust damper linkages for proper damper operation.

C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.

## 3.7 SPARE PARTS:

A. General: Furnish to Owner with receipt one spare set of belts for each belt driven air handling equipment.

## 3.8 COMMISSIONING:

A. Final Checks Before Start-Up: Perform the following operations and checks before start-up:

1. Remove shipping blocking and bracing.

2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Verify manual and automatic volume control and that fire and smoke dampers in connected ductwork systems are in the full-open position.

7. Disable automatic temperature control operators.

B. Starting procedures for fans:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.

2. Replace fan and motor pulleys as required to achieve design conditions.

3. Measure and record motor electrical values for voltage and amperage.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Section 23 05 93 "Testing, Adjusting and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

## 3.9 DEMONSTRATION:

A. Demonstration Services: Arrange and pay for a factory-authorized service representative to train Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shutdown, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals specified in the LPS General Conditions of the Contract and Divisions 20 through 25.

B. Schedule training with at least 7 days' advance notice.

**END OF SECTION 23 34 00**

# SECTION 23 36 00 - AIR TERMINALS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air terminals work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Types of air terminals specified in this section include the following:

1. Central Air Terminals
   a. Shutoff Single Duct
   b. Reheat

2. Fan Powered Terminals
   a. Series
   b. Parallel

C. Refer to other Division 23 sections for related work in addition to the requirements of this section.

D. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on air terminals. Include disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

E. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls and air terminals.
   a. Control wiring specified as work of Section 23 09 23 for Direct Digital Control Systems is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ADC Compliance: Provide air terminals, which have been tested and rated in accordance with ADC standards, and bear ADC Seal.
2. ARI Compliance: Provide air terminals, which have been tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bear ARI certification seal. Hot water coils shall be tested and rated in accordance with ARI Standard 410.

3. NFPA Compliance: Construct air terminals using acoustical and thermal insulations complying with NFPA 90A "Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including performance data for each size and type of air terminal furnished, schedule showing drawing designation, room location, number furnished, model number, size and accessories furnished; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts list for each type of air terminal; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.

B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Air Terminals:
   a. Anemostat Products Division; Dynamics Corp. of America.
   b. Carnes Co.
   c. Trane (The) Co.
   d. Titus Products Division; Philips Industries, Inc.
   e. Tempmaster
   f. Metal-Aire
   g. Krueger

2.2 AIR TERMINALS:

A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.

B. Air terminal units shall be low pressure drop, single duct/ dual--duct throttling type pressure independent and suitable for use in low/medium pressure variable volume [and] constant volume/dual duct air distribution systems.

C. Casing shall be minimum 22 gauge galvanized steel construction with internal acoustical coated 1/2" thick, 1-1/2 lb. density, fiberglass insulation and inlet and outlet duct connections. Provide gasketed and insulated access doors for air terminals with internally mounted serviceable components, including actuators and fan motors.

1. Casing shall be insulated with 1/2", 1-1/2 lb. reinforced foil faced insulation. All edges shall be folded and tucked or protected by sheet metal nosing to isolate all glass fibers from the air stream.

D. Internal damper blade shall be extruded aluminum or 18 gauge steel with keyed fit shaft and nylon bushing. Damper shall seal against gasketed stops maximum 2% leakage at 3.0" S.P. All mechanical parts shall be galvanized or non-ferrous. Alternate damper design as produced by the Trane Company as acceptable.

E. Hot water heating coils shall be designed for 200 psig maximum working pressure and 200$^{o}$F maximum operating temperature. Coil shall be serpentine-type, constructed of 1/2" O.D. copper tubes mechanically bonded to aluminum fins; galvanized steel casing.

OR

Electric heating coils shall be constructed of electric resistance heating elements in galvanized steel casing with a NEMA 1 control box, a hinged access door and factory wiring. Provide over-temperature protection, differential pressure air flow switch, door interlocking disconnect, magnetic contactors and UL listing as duct heater. Provide a minimum of 2 stages for heaters 3 KW and over. Heater shall be located upstream of primary air damper to allow well developed flow across the elements and to provide a strong signal for the air flow proof switch.

EDIT NOTE: Heater upstream of damper is not done by all manufacturers, but is a good idea. Titus- No, Enviro Tec-Yes.

EDIT NOTE: Verify the need for access door in terminal casing with Owner and ASHRAE Standards.

F. Provide between terminal casing and reheat coil, factory-installed framed duct access door complete with quarter-turn quick release fasteners.

G. Provide label on each air terminal unit, indicating plan designation, unit size, cfm range and settings and calibration curve.

H. Provide a pressure independent pneumatic cross or ring-shaped flow sensor with velocity pressure pickup points for measuring inlet airflow. The sensor shall maintain control accuracy with the same size inlet duct in any configuration. Single point hot wire anemometer or straight line pneumatic sensors are not acceptable. Provide gauge ports in flow sensor tubing.

## 2.3 FAN POWERED TERMINALS:

In addition to the above, comply with the following:

A. Fan Section: Provide galvanized steel plenum, acoustically lined, housing forward curved fan with belt or direct driven permanent split capacitor motor with SCR speed control and fan contactor factory wired to power and control terminal blocks in a sheet metal enclosure. Provide air filter and inlet plenum boot.

SPEC WRITER NOTE: See insulation options above.

1. For series, constant volume terminals, the fan shall be mounted in a common compartment with the primary air damper. The fan shall operate continuously drawing a mixture of plenum air and primary air.

2. For parallel, variable air volume terminals the fan shall be mounted in a separate compartment. The fan shall operate intermittently, drawing only plenum air. Provide a back draft damper to prevent primary air from bypassing to the plenum.

B. Heating coil shall be located in the discharge of the terminal, not in the plenum air inlet.

2.4 CONTROLS:

SPEC WRITER NOTE: Use below for all DDC jobs and for select pneumatic jobs (to replace existing pneumatics, only).

A. Air terminal unit manufacturer shall mount DDC controller and DDC actuator provided by the temperature control manufacturer. See Sections 23 09 23 and 23 09 93.

B. Coordinate spring range P/E settings and control action with devices provided under Sections 23 09 23 and 23 36 00 and Sequence of Operation specified in Section 23 09 93.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air terminals are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 COORDINATION:

A. The contractor is responsible for determining the position of controls, actuators, and access. Coordinate each air terminal's position with building elements, piping, conduit, ductwork and other items, order left/right hand units as required and inform all other trades as required. Relocate interfering items or terminal as required to provide proper access if not coordinated beforehand.

3.3 INSTALLATION OF AIR TERMINALS:

A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.

B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

C. Duct Connections: Connect ductwork to air terminals in accordance with Division 23 ductwork sections.

3.4 FIELD QUALITY CONTROL:

A. Upon completion of installation and prior to initial operation, test and demonstrate that air terminals, and duct connections to air terminals, are leak-tight.

B. Repair or replace air terminals and duct connections as required to eliminate leaks, and retest to demonstrate compliance.

3.5 CLEANING:

A. Clean exposed factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.6 BALANCING:

A. See Section 23 05 93. Balancing contractor shall set all air quantity limits, and shall not rely on any factory calibration. Report air quantity as measured by the air terminals velocity pressure pick up, in addition to pitot traverses and outlet readings.

**END OF SECTION 23 36 00**

# SECTION 23 37 13 - AIR DISTRIBUTION DEVICES

PART 1- GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air outlets and inlets work is indicated by drawings and schedules, and by requirements of this section.

B. Types of air outlets and inlets required for project include the following:

Ceiling air diffusers.
Wall registers and grilles.
Louvers.

C. Refer to other Division 23 sections for ductwork, duct accessories, testing and balancing—not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets".

2. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".

3. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".

4. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.

5. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters".

6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.

7. NFPA Compliance: Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.

2. Data sheet for each type of air outlet and inlet and accessory furnished, indicating construction, finish and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Samples: Submit 3 samples of each type of finish furnished.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air outlet and inlet, indicating materials and methods of assembly of components.

D. Record Drawings: At project closeout, submit record drawings of installed systems products, in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air outlets and inlets wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Diffusers, Registers and Grilles:
   a. Anemostat Products Div.; Dynamics Corp. of America.
   b. Carnes Co.; Division. of Wehr Corp.
   c. Price
   d. Krueger; Division. of Philips Industries, Inc.
   e. Titus Products Division; Philips Industries, Inc.
   f. Metal-Aire
   g. Nailor

2. Louvers:
   a. Air Balance
   b. American Warming & Ventilating, Inc.
   c. Arrow United Industries, Inc.
   d. Pottoroff
   e. Louvers & Dampers, Inc.
   f. Penn Ventilator Co., Inc.
   g. Ruskin

2.2 CEILING AIR DIFFUSERS:

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems, which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on air device schedule.

2.3 REGISTERS AND GRILLES:

A. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction, which will contain each type of wall register and grille.

D. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on air device schedule.

2.4 LOUVERS:

A. See Section 08 90 00, LOUVERS AND VENTS, for louvers and vents provided by Division 8.

OR

General: Except as otherwise indicated, provide manufacturer's standard 4" deep X 4" height stationary, stormproof blade type louvers with aluminum bird screen where shown; of size indicated; constructed of aluminum/galvanized steel and components as indicated, and as required for complete installation. Air Balance Model FL-445J (galvanized steel, 4" deep, 45°, fixed style J blades). Louvers shall be Air Balance Model EL-445K (extruded aluminum, 4" deep, 45° fixed style K blades). [LIST MANUFACTURER AND MODEL] or approved equivalent

B. Performance: Provide louvers that have a minimum of 50% free area, and a maximum pressure drop through the free area of not more than 0.075" for each type as listed in manufacturer's current data.

C. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general

construction drawings and specifications for types of substrate, which will contain each type of louver.

D. Materials: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.

E. Louver Screens: On inside face of exterior louvers inside face of exhaust air outlet and outside face of outside air intake louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air outlets and inlets are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air outlets and inlets with other work.

C. Locate ceiling air diffusers, registers and grilles as indicated on general construction "Reflected Ceiling Plans". Unless otherwise indicated, locate units in center of acoustical ceiling modules.

3.3 SPARE PARTS:

A. Furnish to Owner, with receipt, 3 operating keys for each type of air outlet and inlet that require them.

**END OF SECTION 23 37 13**

# SECTION 23 51 00 - BREECHINGS, CHIMNEYS AND STACKS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section specifies double wall metal vents and accessories for gas-fired appliances.
B. This Section specifies refractory lined metal breechings, chimneys, and accessories.
C. This Section specifies field fabricated metal breechings, chimneys, and accessories.

1.2 SUBMITTALS:

A. Product Data: Submit product data including materials, dimensions, weights, sizing and accessories.

B. Shop Drawings: Submit shop drawings including required clearances, assembly and installation instructions, and support of components.

1. The Sheet Metal Contractor shall submit a computerized vent sizing analysis for the actual boilers and water heaters being furnished. The computer analysis shall list the make, model number, firing rate, and the allowable back pressure for each appliance, the quantity and type of each component, the draft conditions with each appliance firing individually and with all appliances firing. The Contractor shall also provide drawings showing all components and their location in the system.

NOTE:
a. All parts exposed to outside atmosphere shall be coated by the installer, with one base coat and one finish coat of Glidden, Metallite, or approved equal.
b. In lieu of painting all exposed parts, a 304 SS or 316 SS outer may be specified.

C. Quality Control Submittals:

1. Certificates: Submit certificates of materials compliance with specified ASTM, UL and ASHRAE requirements.

2. Certificates: Submit Welders' Qualification Certificates.

3. Certificates: Submit complete engineering report certifying that stacks meet the design wind and seismic loads.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 20 through 25.

1.3 QUALITY ASSURANCE:

A. Welder's Qualifications: All welders shall be certified in accordance with AWS Standard D9.1, Specifications for Welding Sheet Metal.

B. Codes and Standards:

1. NFPA: Comply with NFPA 211 "Standard for Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances."

2. UL: Comply with applicable portions of UL safety standards; provide products which have been UL listed and labeled.

3. SMACNA: Comply with SMACNA Low Pressure Duct Standards for fabricated breeching and smokepipe.

4. AWS: Comply with AWS Structural Welding Code for welders' qualifications, welding details, and workmanship standards.

5. ASHRAE: Comply with the ASHRAE Equipment Handbook, Chapter 27, for Chimney, Gas Vent, and Fireplace Systems, material requirements and design criteria.

6. UMC: Comply with I.A.P.M.O. Uniform Mechanical Code for chimney application and requirements of stack type, height and clearances.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

A. Double Wall Metal Vents:
1. American Metal Products Co.; Div. of Masco Corp.
2. General Products Co., Inc.
3. Hart & Cooley Mfg. Co.
4. Metal Fab
5. Selkirk Metalbestos.
6. Simpson Dura-Vent.

B. Refractory Lined Metal Breechings and Chimneys:
1. Van Packer Co.
2. Power Pac Enterprises, Ltd.
3. Susquehanna Concrete Products, Inc.
4. Stacks, Inc., Div of Air Management, Inc.

C. Fabricated Metal Breechings and Chimneys:
1. Van Packer
2. American Metal Products Co.; Div. of Masco Corp.

2.2 DOUBLE WALL METAL VENTS:

A. Type B Gas Vents (Gas-Burning Appliances Only):

1. Description: Double wall gas vents, UL listed for Type B, consisting of an inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, with the following minimum thicknesses:

| Size | Inner Pipe | Outer Pipe |
|---|---|---|
| Round, up to 6" | 0.012" | 28 gauge |
| Round, 7" to 18" | 0.014" | 28 gauge |
| Round, 20" to 24" | 0.018" | 26 gauge |
| Oval, up to 4" | 0.012" | 28 gauge |
| Oval, 5" to 6" | 0.014" | 28 gauge |

2. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners, fabricated of similar materials and designs as vent pipe straight sections.

B. All Steel, Positive Pressure, Double and Triple Wall Vents:

1. Description: UL-labeled double and triple wall metal stacks for use with building heating equipment burning gas, solid, or liquid fuels not exceeding 1000 degrees F. continuous and capable of maintaining airtight integrity at pressures up to 72inches W.C. as described in NFPA 211 and UL 103.

2. Construction: All stacks and breechings will have inner walls of 20 ga. (Type 304 Stainless Steel for gas and No. 2 Oil) or (Type 316 Stainless Steel for solid fuels, or No. 4 thru No. 6 Oil). The outer jacket shall be 24 ga. aluminum coated steel for sizes up to 24inches I.D. and 20 ga. for sizes 26inches I.D. and larger. There shall be minimum 1" air space between the inner and outer walls.

3. Accessories: UL-labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, fire stop spacers, and fasteners fabricated of similar materials and designs as vent pipe straight sections.

2.3 REFRACTORY LINED METAL BREECHINGS AND CHIMNEYS:

A. Design Loads:

1. Wind Loading: 110 mph.
2. Seismic Loading: Zone 1.

B. Steel Jacket:
1. Chimney Outer Jacket:
   a. 26 gauge aluminized steel with riveted seams.
   b. 11 gauge galvanized steel with welded seam joint.

2. Breeching Outer Jacket: 11 gauge galvanized steel with welded seams.

C. Refractory Lining:

1. Tested under UL Standard 959 for temperature and acid resistance, and bearing the testing laboratory label.

2. Temperature: Withstand 1800 degrees F continuous firing, and 2000 degrees F intermittent firing without fusion.

3. Acid Extraction: Maximum of 0.2 percent.

4. Cold Crushing Strength: Minimum of 3,200 psi.

5. Bond refractory lining to steel jacket so finished product may be shipped, handled, and installed with no separation.

6. Thickness: Minimum of 2inches.

7. Finishing: Factory-applied, high heat resistant paint, color as selected by the Architect/Engineer.

D. Accessories: Provide accessories bearing UL label.

1. Base Section: Provide acid resistant coated cast-iron anchor lugs for securing stack to foundation.

2. Cleanout Section: Provide smoke-tight cleanout section with gasketed and bolt-tightened inspection plate. Weld neck to stack section.

3. Tee or Wye Section: smoke-tight tee or wye as indicated for breeching connection, with welded joints, refractory lining, finished with smooth transition, and with no exposed metal on inside.

4. Spark Screen: Type 304 stainless steel, 16 gauge, 1/2 x 1/2 inches mesh, with Type 304 stainless steel rolled angle and drawband.

5. Guy bands: 8inches wide bands of same material as jacket, fastened with nuts and bolts for tight fit.

6. Roof Penetration: factory fabricated thimble, flashing, and counterflashing.

E. Fabrication:

1. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.

2. Fabricate components with centrifugally cast lining in lengths suitable for connection with drawband. Bond refractory with calcium aluminate cement.

3. Fabricate chimneys with anchor lugs, cleanout, T- sections, flashing and counterflashing, and provisions for support, expansion, and contraction.

4. Fabricate breechings with support lug for attachment to building structure so as not to exceed permissible loading at appliance and chimney.

2.4 FABRICATED METAL BREECHINGS AND CHIMNEYS:

A. Materials:

1. Black, carbon, hot-rolled steel complying with ASTM A 569, except breechings less than 24inch diameter (or longest side) may be galvanized sheet steel complying with ASTM A 527, lock forming quality with ASTM A 525, G90 zinc coating, mill phosphated.

2. Minimum gauges for corresponding sizes as indicated (diameter or longest side dimension):

| SIZES | THICKNESS - Gauge |
|---|---|
| up to 12" | 18 |
| 13" to 24" | 16 |
| 25" to 36" | 14 |
| 37" to 60" | 12 |
| over 60" | 10 |

B. Fabrication:

1. Shop fabricate breechings and chimneys in as complete as possible to minimize field welding. Match-mark sections for field assembly and coordination of installation.

2. Longitudinal Seams: welded, except longitudinal seams for breechings less than 24inches diameter (or longest side) may be Acme grooved type.

3. End joints: weld, lap and bolt, or use companion flanges; except breechings less than 24inches diameter (or longest side) may have end joints beaded and crimped.

4. Reinforcement: Reinforce rectangular breechings with angle frames as follows for corresponding long side dimensions; and reinforce round breechings with either flanged girth joints or angle frames as follows for corresponding diameter:

| SIZES | REINFORCING | INTERVAL |
|---|---|---|
| up to 30" | No reinforcing required. | |
| 31" to 36" | 1-1/2" x 1-1/2" x 3/16" | 30" o.c. |
| 37" to 60" | 2" x 2" x 1/4" | 30" o.c. |
| over 60" | 3" x 3" x 1/2" | 30" o.c. |

5. Fabricate breeching and chimneys fittings to match adjoining materials. Except as otherwise indicated, fabricate elbows with centerline radius equal to associated breeching width. Limit angular tapers to 20 degrees maximum for expanding tapers. Install accessories during fabrication to greatest extent possible.

C. Accessories and Specialties:

1. Provide accessories and specialties of types and sizes required to comply with breeching requirements including proper connection of equipment.

2. Barometric Dampers: adjustable, self-actuating draft dampers, where indicated, full size of breeching.

3. Cleanout Doors: same gauge as breeching; size and location as indicated.

4. Thermally Actuated Vent Dampers: same size as draft hood collar; constructed of stainless steel housing and brackets. Secure 4 quadrants to brackets constructed of corrosion resistant bi-metal. Secure brass weights to quadrants to prevent vibrations and noise during high draft conditions. Test units in accordance with AGA standards, and certify design complies with ANSI Z21.68.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF DOUBLE WALL CONNECTORS, BREECHINGS AND VENTS:

A. Install Type B gas vents in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.

B. Install all steel, positive pressure, double and triple wall gas vents in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing. The system shall have a 10 inch minimum clearance to combustibles with flue gases not exceeding 1000 degrees F. continuous.

C. Seal joints between sections of positive pressure vents in accordance with manufacturer's installation instructions, and using only sealants recommended by manufacturer. The inner pipe joints shall be field sealed with Containment Bands and high temperature sealant.

D. Support vents at intervals recommended by manufacturer to support weight of the vent and all accessories, without exceeding loading of appliances. Stacks extending above the roof must terminate a minimum of 3 ft 0in above the roof or parapet per NFPA 211 or as required by Code.

E. Provide guy wire support of roof stacks in accordance with manufacturer's recommendations.

### 3.2 INSTALLATION OF REFRACTORY LINED BREECHINGS AND CHIMNEYS:

A. Assemble and erect stack sections and accessories in accordance with the manufacturer's written instructions and in compliance with UL listing. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

B. Joints:

1. Join sections with acid-resistant joint cement for continuous joint and smooth interior finish.

2. Weld joints. Comply with the workmanship quality standards specified in AWS D9.1, Specifications for Welding of Sheet Metal.

C. Erect chimneys level and plumb to finished tolerance of no more than 1inch out of plumb from top to bottom.

D. Erect breechings with a slope down to appliance, with condensate drain connection. Pipe drain line to nearest open site drain.

E. Field painting is specified in Division 9 including touch- up or refinishing sections or accessories that are scratched or marred during shipping and handling, or require touch-up after welding.

3.3 INSTALLATION OF FABRICATED BREECHINGS AND CHIMNEYS:

A. Assemble and erect fabricated breechings and chimneys in accordance with SMACNA Low Pressure Duct Construction Standards.

B. Joints: Weld joints in conformance with AWS workmanship standards of AWS D 9.1, Specification for Welding Sheet Metal.

C. Align breechings accurately at connections, with a smooth internal surface and a 1/8inch misalignment tolerance.

D. Slope breechings down to appliances and provide a condensate drain connection. Pipe drain line to nearest open site drain.

E. Install concrete inserts for support of breeching in coordination with formwork.

F. Install accessories, dampers, fans, equipment, controls, and other supports.

G. Anchor breechings to building structure with bolts, concrete inserts, steel expansion anchors (not lead-shield type), welded studs, C-clamps or special beam clamps.

H. Vertical Breechings:

1. Support at 12 foot intervals, by attachment to adjacent vertical structural surfaces or by direct bearing at floor penetrations and similar locations.

2. Breechings up to 24inch x 20inch: use 1-1/2inch x 16 gauge straps or formed angles.

3. Breechings larger than 24inch x 20inch: use steel angle brackets 1inch x 1/8inch for sizes up to 36inch x 18inch; 1-1/2inch x 1/8inch for larger sizes.

I. Horizontal breechings located against structural walls and other similar adjacent vertical surfaces:

1. Support at 8-foot intervals for units up to 40inch horizontal dimensions, and 4 foot intervals for larger breechings.

2. Where width is less than height, support with 1-1/2inch x 16 gauge straps.

3. Where width is more than height, support with shelf- type fabricated angle brackets: 1" x 1/8" for widths up to 18inches, 1-1/2inch x 1/8inch for greater widths.

J. Horizontal Rectangular Breechings:

1. Support from overhead structure with hangers at 10 foot intervals for unit widths up to 60inches, and 8 foot intervals for larger breechings.

2. Support breechings directly with 1inch x 16 gauge straps up to 60inches width, and with 1-1/2inch x 12 gauge straps up to 96inch width, bolted to breechings.

K. Trapeze Hangers:

1. Support breechings with horizontal angle members and vertical support members of sizes listed below (long side dimensions):
   a. Up to 30 inches size: 1inch x 1/8inch angle, with 1inch x 18 gauge or 1/4inch diameter hangers.
   b. 31inches to 60 inches size: 1-1/2inch x 1/8inch angle, with 1-1/2inch x 16 gauge or 3/8inch diameter hangers.
   c. 61inches to 84inches size: 2inch x 1/8inch angle, with 1-1/2inch x 14 gauge or 1/2inch diameter hangers.
   d. Over 84 inches size: 2inch x 1/4inch angle, with 5/8inch diameter hangers, except as otherwise shown.

L. Horizontal Round Breechings:

1. Support with girth strap and strap hanger (of same size); except for sizes over 50inches in diameter. Install pair of strap hangers bolted to opposite sides of angle reinforcing rings or flanged joints. Support breechings at 10 foot intervals with hangers as follows for corresponding diameters.
   a. Up to 30inch diameter: 1inch x 16 gauge strap hangers.
   b. 31inches to 50inches diameter: 1-1/2inch x 16 gauge strap hangers.
   c. 51" to 84" diameter: Pairs of 1-1/2inch x 16 gauge hangers.

3.4 INSTALLATION OF DAMPERS:

A. Install barometric and thermostatically operated dampers in accordance with manufacturer's instructions. Locate as close to draft hood collar as possible.

3.5 ADJUSTING AND CLEANING:

A. Clean breechings internally during installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.

3.6 PROTECTION:

A. Temporary Closure: At ends of breechings and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until installations are completed.

**END OF SECTION 23 51 00**

# SECTION 23 52 00 - BOILERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of boiler work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to Division 3 for concrete pads; not work of this section.

C. Refer to other Division 20 through 25 sections for piping, specialties, water treatment, pumps, breechings, temperature controls, etc., required external to boilers for installation; not work of this section.

D. Electrical Work: Refer to Section 23 05 13 and Division 26 for requirements.

E. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 26:

1. Furnish to Electrical Installer, burner emergency shutoff switch.

2. Provide control wiring between boiler control panel and thermostats, aquastats, pressurestats, or any other control device.

3. Provide factory-mounted and wired controls and electrical devices as specified in this section.

F. Refer to Division 26 sections for other electrical work including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of boilers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Manufacturer's Test: All boilers shall be factory assembled and tested. Submit test results to Architect/Engineer prior to shipping.

C. Codes and Standards:

1. Cast Iron Boilers:

a. I=B=R Compliance: Provide cast-iron boilers that have been tested and rated in accordance with Institute of Boiler and Radiator Manufacturers (I=B=R) "Testing and Rating Standard for Cast-Iron and Steel Heating Boilers", and bear I=B=R emblem on nameplate affixed to boiler.
b. NFPA Compliance: Install oil-fired cast-iron boilers in accordance with NFPA Standard 31 "Standard for the Installation of Oil Burning Equipment".
c. NFPA Compliance: Install gas-fired cast-iron boilers in accordance with NFPA Code 54 "National Fuel Gas Code".
d. ASME Compliance: Construct cast-iron boilers in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers". Controls shall be per ASME.

e. UL and NEMA Compliance: Provide cast-iron boiler ancillary electrical components, which have been "listed" and "labeled" by UL, and comply with NEMA standards. "Listed" and "labeled" shall be defined by NEC, Article 100.

SPEC WRITER NOTE: Retain below for projects insured by companies that require FM compliance.

f. FM Compliance: Provide control devices and control sequences in accordance with requirements of Factory Mutual System (FM).

g. IRI Compliance: Provide control devices and control sequences in accordance with requirements of Industrial Risk Insurers (IRI).

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), furnished specialties, flue sizing recommendations and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, loadings, required clearances, and method of field assembly, components and location and size of each field connection.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to cast-iron boilers. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of cast-iron boilers and controls. Clearly differentiate between portions of wiring that are factory installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts list for each cast-iron boiler, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle boiler sections and equipment carefully to prevent damage, breaking, and scoring. Do not install damaged sections or components; replace with new.

B. Store boiler sections and equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and moving instructions for unloading boilers, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Cast Iron Boilers:
   a. Burnham
   b. H. B. Smith
   c. Peerless
   d. Weil-McLain; A Division of the Marley Co.

2. Cast Iron Modular Boilers:
   a. Hydrotherm
   b. Weil-McClain

3. Packaged Steel Water Tube Boilers:
   a. Bryan
   b. Cleaver-Brooks

4. Packaged Steel Fire Tube Boilers:
   a. Cleaver-Brooks
   b. Kewanee

2.2 CAST IRON PACKAGED GAS-FIRED BOILERS:

A. General: Provide as indicated, factory-assembled and fire-tested packaged fully modulating gas-fired boilers, of capacity as scheduled. Provide design certified by AGA, net ratings approved by I=B=R, heating capacities based on standard test procedures prescribed by DOE, and constructed in accordance with requirements of the ASME Boiler and Pressure Vessel Code.

B. Boiler: Construct of cast-iron sections, set on insulated steel base, with sections sealed with high-temperature sealant, and held together with tie rods.

C. Equipment: Provide insulated extended jacket, vertical draft hood, aluminized steel burners, stainless steel radiation plates, combination gas control valve for 24- volts, 100percent shutoff, thermocouple, built-in air eliminator, non-linting pilot burner, ASME safety/pressure relief valve, automatic air vent, combination pressure-temperature gauge, combination relay receptacle and 40 VA transformer, plug-in circulator relay, automatic low water fuel cutoff, operating controls per ASME, high-limit control, electrical junction box, wiring harness and safety control wiring, circulator, compression tank with backflow preventor shut-off valve, boiler drain valve and blowdown valve.

D. Accessories: In addition to above, provide intermittent electronic ignition system, and automatic vent damper.

E. [Edit] Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of boilers.

2.3 CAST IRON MODULAR GAS-FIRED BOILERS:

A. General: Provide as indicated, factory-assembled and tested cast-iron, gas-fired fully modulating, modular hot water boilers, designed to be operated in battery of boiler modules, of capacity as scheduled. Provide design certified by AGA, net ratings approved by I=B=R, and constructed in accordance with requirements of the ASME Boiler and Pressure Vessel Code.

B. Boiler: Construct of horizontal cast-iron sections, connected with push nipples, and provided with cast-iron flue collector.

C. Equipment: Provide for each module, steel burner base with lanced steel atmospheric type gas burners, thermocouple type safety pilot, automatic gas valve, pressure regulator, high limit control, automatic low water fuel cutoff, operating controls per ASME and AGA, certified draft hood. Provide for each battery of boiler modules, ASME safety/pressure relief valve, and insulated steel jacket.

D. Controls: Provide gas controls designed to fire each module in battery in step sequence. Arrange controls so any module can be made inoperative without interfering with normal operation of other modules.

1. Each boiler shall be protected from over temperature by two temperature operated controls per ASME.
2. Each boiler shall be protected by automatic low water fuel cutoff.
3. Each boiler shall have a flow sensor device installed in the outlet pipe to automatically cut off fuel supply when the flow is interrupted.

E. Accessories: In addition to above, provide the following accessories:

1. Prefabricated header set.
2. Domestic hot water heat exchanger.

F. [Edit] Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of boilers.

2.4 CAST IRON COMMERCIAL GAS-FIRED BOILERS:

A. General: Provide as indicated, factory-assembled and tested gas-fired fully modulating cast-iron boilers, of capacity as scheduled. Provide design certified by AGA, net ratings approved by I=B=R, and constructed in accordance with requirements of the ASME Boiler and Pressure Vessel Code.

B. Boilers: Construct of cast-iron sections, sealed with asbestos rope, and assembled with tie rods.

C. Equipment: Provide insulated jacket, horizontal to vertical draft hoods, built-in air eliminator, factory-assembled base and burners, prepiped gas control assemblies, aluminized steel burners, manual main shutoff gas valves, pilot shutoff valves, high pressure gas switches, 40VA transformer, electrical junction box, and flue brush.

1. Provide intermittent electronic ignition system consisting of electronic control, electronic supervised pilot, combination automatic gas valves and pressure regulators, redundant gas valves, pilot filters, and automatic 100 percent shutoff.
2. Provide for water boilers high-limit control, operating control, per ASME combination pressure-temperature- altitude gauge, automatic low water fuel cut off and ASME safety relief valve (15 psig).
3. Provide for steam boilers automatic low water fuel cutoff, pressure high limit control, operating pressure control, per ASME, steam pressure gauge (0-30 psig), gauge glass set with gauge cocks, siphon, and ASME safety relief valve (15 psig).

D. Accessories: In addition to above, provide the following accessories:

1. Tankless water heater.
2. Low water cutoff and feeder combination.
3. 1-1/2inch inspection opening with brass plug for each section.
4. Pilot pressure regulator.
5. Multi-stage firing.
6. Electronic flame safeguard control system with panel.
7. High-Low-Off firing.
8. Full modulation firing.
9. Flow switch.

E. [Edit] Provide services of a factory-authorized service representative to supervise field assembly of components and installation of boilers.

2.5 CAST IRON FORCED DRAFT BOILERS:

A. General: Provide as indicated, factory assembled and tested package, forced draft cast-iron, fully modulating boilers of capacity as scheduled. Provide net ratings approved by I=B=R, and construct in accordance with requirements of ASME Boiler and Pressure Vessel Code.

B. Boiler: Construct of cast-iron sections with integral base, sealed with asbestos rope for gas-tight construction, factory-assembled and tested.

C. Equipment: Provide insulated flush jacket, burner mounting plate with refractory. Provide water-backed combustion area with water circulating around firebox, access to flow passages for cleaning and flame observation ports. flue collar with built-in breeching damper, front cleanout doors and plates, back access door, flue brushes and handles, close nipples and caps for washout tappings on front and back sections, and supply elbows or top outlets.

1. Provide intermittent electronic ignition system consisting of electronic control, electronic supervised pilot, combination automatic gas valves and pressure regulators, redundant gas valves, pilot filters, and automatic 100 percent shutoff.

2. Provide for hot-water boilers ASME relief valve (15 psig), combination high-limit control, automatic low water fuel cutoff, operating pressure controls per ASME, and combination pressure-temperature-altitude gauge.

3. Provide for steam boilers ASME safety relief valve (15 psig), automatic low-water fuel cutoff, low-limit and high-limit pressure controls, operating controls per ASME, steam pressure gauge (0-30 psig), siphon, gauge glass set with gauge cocks.

D. Accessories: In addition to above, provide the following accessories:

1. Water level controls.
2. Auxiliary Low water cutoff and feeder combination.
3. Barometric damper.
4. 1-1/2inch side inspection openings with plugs.
5. Tankless water heater.
6. Flow switch.
7. Pilot pressure regulator.
8. Multi-stage firing.
9. High-Low-Off firing.
10. Full modulation firing.

E. Burner: Provide flame retention power burner for oil, gas, or gas-oil as scheduled. Provide burner mounted, factory- wired control panel for operation as scheduled.

Edit the following control to be provided with Boiler. Provide auxiliary contracts if connected to B.A.S. for monitoring.

F. Operating Temperature Control: Electric indoor/outdoor controller maintains boiler water temperature with outdoor temperature reset.

OR

Operating Temperature Control: Electronic operating temperature controller maintains boiler water temperature with electronic primary and outdoor sensors. Reset ratio of outside air temperature change to discharge control point changes adjustable from 1:2 to 100:1, with

adjustable initial set point from 80 to 230 degrees (27 to 110 degrees C.) Mounted in NEMA250, type 1 wall mounted enclosure with full cover.

G. [Edit] Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of boilers.

H. Combination Burner Controls: Pre-wired factory assembled electronic controls in control cabinet with flame scanner or detector, programming control, relays and switches. Performs pre-purge and post-purge for ignition, and shuts down burner in event of ignition pilot and main flame failure, with manual reset.

I. Hot Water Boiler Trim:

1. Hot water connections: Supply and return connection locations shall provide internal thermal circulation which will mix return water with hot water in boiler.

2. Drain Valves: Provide at low points.

3. Dip tube: An integral part of the hot water outlet, and air vent tapping in boiler shell for removal of entrained air.

4. Low water cutoff: Mounted on the side of boiler; factory-wired into burner control circuit to prevent burner operation if boiler water falls below safe level.

5. Pressure and temperature gauges: Mounted on boiler, with temperature sensing element located adjacent to the hot water outlet.
   a. Water pressure relief valves: Of type and size to comply with ASME Code requirements.
   b. Temperature controls: To regulate burner operation; mounted temperature sensing elements adjacent to hot water outlet.
   c. Operating controls per ASME.
   d. Safety pressure controls: High-pressure-limit control.

J. Gas Burner: High radiant multiport type burner, integral with front head of boiler, approved for operation with natural, manufactured, or mixed gas.

1. Operation:

Select one of the Following.

a. Burner Operation and Combustion Air Control: On-off principle with manually operated combustion air damper for proper air-fuel ratios. *Use for 15-20 BHP.

OR

Burner Operation and Combustion Air Control: High-low-off with motor-operated combustion air damper, linked with auxiliary switch; controls high or low fire gas supply. Return burner to low fire position for ignition. *Use for 30-40 BHP.

OR

Burner Operation and Combustion Air Control: Full modulation principle, 4-to-1 turndown ratio. Motor-operated combustion air damper and cam-operated butterfly gas-metering valve, operated by a single damper-control motor.

Regulate fire according to load demand. Damper motor operated by potentiometer type positioning controls. Burner returned to low fir position for ignition. *Use for 50-800 BHP.

b. Return burner to low fire position for ignition.

2. Gas pilot: premix type with automatic electric ignition, complete with electronic detector to monitor pilot so primary fuel valve cannot open until pilot flame has been established.

3. Forced draft blower: for combustion air, mounted on front of boiler, with steel blower wheel and radial blades, directly connected to flanged type motor.

4. Combustion Air Control:

Select one of the Following.

a. Manually operated damper for proper air-fuel ratios. *Use for 15-20 BHP.

OR

Motor-operated combustion air damper, linked with auxiliary switch to control high or low fire gas supply. *Use for 30-40 BHP.

OR

Motor-operated combustion air damper and cam-operated butterfly gas metering valve, operated by single damper control motor to regulate fire according to load demand. Operation of damper control motor shall be regulated by potentiometer type positioning controls. *Use for 50-800 BHP.

5. Gas burner piping: integrally mounted, including primary gas shutoff valve, motor operated with spring return, designed to start and stop gas burner, and to close automatically in event of power failure, flame failure, or low water condition. Gas train shall include lubricated plug cock located upstream of primary valve for manual shutoff, plugged leakage test cock and second lubricated plug cock; additional devices required include:
   a. A proof of closure switch on primary valve, and high and low gas pressure switches. *Use for 60-800 BHP.

   OR

   A second motorized safety shutoff valve and additional plugged leakage test cock, with proof-of-closure switch and manual reset. *Use for 125-800 BHP.

   OR

   A vent valve located between safety shutoff valves. *Use for 300-800 BHP.

6. Control panel: NEMA 1A control panel mounted on front of boiler, complete with an electronic programming relay, blower motor starter, and control switches. Panels shall include:
   a. Plug-in fuel modules, and indicating lights for low water level, flame failure, fuel valve open, and load demand; Delete for units less than 50 BHP.
   b. Programming relay, to control ignition timing and starting and stopping burner through pre-combustion purge and post-combustion purge, plus a flame scanner to shut down burner in event of ignition, pilot, or main flame failure.
   c. Manual-automatic selector switch and damper motor positioning switch to permit automatic firing in accordance with load demand, or manual control of firing rate at any desired point between low fire and maximum rating; (Delete for units less than 30 BHP).
   d. Factory-wired UL-labeled electrical equipment. Use oil, heat, and moisture resistant wire throughout.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which boilers are to be installed, and substrate which will support boilers. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF CAST-IRON BOILERS:

A. General: Install boilers in accordance with manufacturer's installation instructions, in accordance with State and local code requirements, and in accordance with requirements of local Utility Company. Install units plumb and level, to tolerance of 1/8inch in 10'-0" in both directions. Maintain manufacturer's recommended clearances around and over boilers.

B. Support: Install boilers on 4-inch thick concrete pad, 6inches larger on each side than base of unit.

C. Erection: Assemble boiler sections in proper sequence and with sealing between each section. Assemble boiler trim shipped loose, or unassembled for shipment purposes. Follow manufacturer's installation instructions.

D. Electrical Work: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical work installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment Installer.

E. Gas Piping: Refer to Section 23 11 23 "Natural Gas Systems". Connect gas piping to boiler, full size of boiler gas train inlet; provide union with sufficient clearance for burner removal and service.

F. Oil Piping: Refer to Section 23 11 13 "Fuel Oil Systems". Connect oil piping to boiler, full size of inlet to burner; provide shutoff valve and union with sufficient clearance for burner removal and service.

G.

H. Hot Water Piping: Refer to Section 23 21 00 "Hydronic Piping". Connect supply and return boiler tappings as indicated, with shutoff valve and union or flange at each connection.

I. Steam and Condensate Piping: Refer to Section 23 22 00 "Steam and Condensate Piping". Connect supply, return, and blowdown boiler tappings as indicated, with shutoff valve and union or flange at each connection.

J. Breeching: Refer to Section 23 51 00 "Breechings, Chimneys and Stacks". Connect breeching to boiler outlet, full size of outlet. Route as indicated.

3.3 FIELD QUALITY CONTROL:

A. Flush and clean boilers upon completion of installation, in accordance with manufacturer's start-up instructions.

B. Hydrostatically test assembled boiler and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.

C. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boiler piping, observation of hydrostatic testing, and for certification of completed boiler units.

D. Start-up boilers, in accordance with manufacturer's start-up instructions and in presence of boiler manufacturer's representative. Test controls and demonstrate compliance with requirements. Adjust burner for maximum burning efficiency. Replace damaged or malfunctioning controls and equipment.

3.4 CLOSEOUT PROCEDURES:

A. [Edit] Owner's Instructions: Provide services of manufacturer's technical representative for one 8-hour day to instruct Owner's personnel in operation and maintenance of boilers.

3.5 ADJUSTING AND CLEANING:

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

B. Mark calibrated name plates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

C. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.6 DEMONSTRATION:

A. Services: After testing and inspection is complete, provide the services of an authorized factory service representative to perform start-up and operation demonstration service.

B. Start-up: Perform services in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

C. Maintenance and Operation Training: As a part of the maintenance and operating instructions, review data in operating and maintenance manual, including preventative maintenance schedule and procedures, and procedures for obtaining repair parts and technical assistance. Demonstrate all phases of operation including start-up and shut-down.

1. Schedule training with Owner, provide at least 7-day notice to Architect/Engineer.

D. Provide Combustion Test Record for each Boiler, including a minimum of the following information submitted following the test.

TIME:
DATE:
FUEL: NATURAL
GAS BTU/LB Mid Range
Manifold Pressure: ____ WCI
Steam Pressure: ____PSI

| | |
|---|---|
| COMBUSTION EFFICIENCY: | % |
| AMBIENT TEMPERATURE: | $^{o}$F. |
| STACK TEMPERATURE: | $^{o}$F |
| OXYGEN: | % |
| CARBON MONOXIDE: | PPM |
| CARBON DIOXIDE: | % |
| COMBUSTIBLEGASES: | % |
| STACK DRAFT | (INCHES $H_2O$): |

| | |
|---|---|
| EXCESS AIR: | % |
| OXIDES OF NITROGEN: | PPM |
| SULFUR DIOXIDE: | PPM |
| CARBON MONOXIDE ALARM: | PPM |
| TEST PERFORMED BY: | _____ |

3.7 EXTRA STOCK:

A. For Condensing Boilers, in addition to startup salt, furnish ten 80-lb bags of salt on a pallet and store where requested by Owner. Obtain a receipt from Owner for this salt.

**END OF SECTION 23 52 00**

# SECTION 23 53 00 - BOILER ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of boiler accessories work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Divisions 20 through 25 sections for boilers, piping; piping specialties; control; pump; safety and pressure relief valves; water treatment; concrete pads etc., required for installation of boiler accessories.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of boiler accessories, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ASME Compliance: Construct and install boiler accessories in accordance with ASME "Boiler and Pressure Vessel Code". Install boiler accessories in accordance with ASME B31.1 "Power Piping", or ASME B31.9 "Building Services Piping", as applicable.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicating weights (shipping, installed, and operating where applicable), furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electrically operated boiler accessories. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts lists for each boiler accessory, including "troubleshooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Boiler Valves:

a. Crane Co.; Valves and Fittings Div.

b. Hammond
c. Jenkins Bros.
d. Lunkenheimer (The) Co.; Div. of Conval Corp.
e. Powell (The Wm.) Co.
f. Walworth Co.

2. Safety Valves (Steam):
a. Kunkle Valve Co., Inc.
b. Lunkenheimer (The) Co.,; Div. of Conval Corp.
c. Spirax Sarco, Inc.
d. Watts Regulator Co.

3. Pressure Relief Valves (Water):
a. Amtrol, Inc.
b. Bell & Gossett ITT.
c. Spirax Sarco Co.
d. Watts Regulator Co.

4. Boiler Blowdown Separators:
a. Cleaver Brooks; Div. Aqua-Chem, Inc.
b. Penn Separator Corp.
c. Wessels Co.

5. Boiler Economizers:
a. Kentube; Div. of Tranter, Inc.

## 2.2 BOILER VALVES:

A. General: Provide factory-fabricated boiler valves recommended by manufacturer for use in service indicated. Provide boiler valves of types and pressure ratings indicated for each service, or if not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide sizes as indicated, with connections which properly mate with pipe, tube, and equipment connections.

B. Stop and Check Valves: Construct body of cast iron, ASTM A 126, Grade B, pressure rated for 250 PSI at 450 degrees F (232 degrees C) steam. Provide OS&Y construction, straight or angle pattern with flanged ends, and renewable bronze disc and seat ring.

C. Y-Type Blowdown Valves: Construct body of bronze, ASTM B 62, pressure rated for 150 PSI steam. Provide Y-type globe construction, bronze seat ring, renewable composition disc, screw-in bonnet, and threaded ends.

D. Y-Type Blowdown Valves: Construct body of bronze, ASTM B 62, pressure rated for 300 PSI steam. Provide Y-type globe construction, bronze seat ring, renewable composition disc, screw-in bonnet, threaded ends.

## 2.3 SAFETY AND RELIEF VALVES:

A. Steam Safety Valves: Provide steam safety valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, constructed in accordance with ASME Boiler and Pressure Vessel Code.

1. Bronze Safety Valves: Construct housing of cast bronze, disc and nozzle of forged copper alloy, lap seats to optical flatness. Set valve to relieve at 10 PSI above operating pressure.

2. Cast-Iron Safety Valves: Construct of cast iron, with all bronze/brass trim, and fully enclosed spring. Set valve to relieve at 10 PSI above operating pressure.

3. Drip Pan Elbows: Provide drip pan elbows on steam safety valves required to discharge to outdoors. Construct of cast iron, with bottom drain and pan drain connections.

4. Exhaust Heads: Provide exhaust heads on exhaust steam lines, constructed of cast iron, and consisting of helico-centrifugal chamber and drain.

B. Water Relief Valves: Provide water relief valves as indicated, of size and capacity as selected by Installer for proper relieving capacity, constructed in accordance with ASME Boiler and Pressure Vessel Code.

1. Pressure Relief Valves: Construct of bronze body, metallic disc, metal seat, with non-mechanically guided stem. Set valve to relieve at 10 PSI above operating pressure.

## 2.4 BOILER BLOWDOWN SEPARATORS:

A. General: Provide as indicated, boiler blowdown separators of size and capacity noted on drawings.

B. Tank: Construct of carbon steel, with tangential inlet pipe and stainless steel striking plate, vent opening, discharge opening with spiral formed discharge directing plate, supported on 3 support legs of indicated height.

C. Water Inlet: Provide cold water inlet in discharge pipe, and 2 thermometer wells.

D. Specialties: Provide temperature regulating valve in water inlet with temperature sensing bulb in lower thermometer well; bi-metallic thermometer in upper thermometer well; and Y-type strainer in cold water inlet line upstream of temperature regulating valve. Provide backflow prevention device in water inlet.

## 2.5 BOILER WATER TREATMENT FEEDERS:

A. See Section 23 25 00, "WATER TREATMENT".

## 2.6 BOILER ECONOMIZERS:

A. General: Provide finned tube boiler economizers of sizes and having capacities and performance characteristics as indicated, and as specified herein.

B. Type: Provide horizontal tube, counter-current flow arrangement, designed, manufactured, and tested in accordance with ASME Boiler and Pressure Vessel Code. Provide ASME Stamp.

C. Construction: Construct economizer heating surface of 2inch O.D. boiler tubes with smooth carbon steel fins, not less than 0.07inches thick, attached by continuous high-frequency resistance welding. Provide maximum fin density (pitch) of 60 fins/ft.

D. Tube Arrangement: Provide square pitch for lane blowing of soot-blowers.

E. Headers: Provide schedule 40 carbon steel pipe with minimum 300 PSI flanged connections. Provide 3/4inch drain connection on lower header, and 3/4inch vent connection in upper header.

F. Enclosure: Provide gas-tight, hot structure design allowing unrestricted flow of hot gas over internal parts. Allow fin tips only, not tube walls, to be in contact with tube sheets. Construct inner casing of enclosure of 3/16inches thick carbon steel. Furnish enclosure with minimum of

2inches thick, factory-installed, high temperature insulation covered with corrugated, galvanized, carbon steel jacket. Paint exterior surfaces not covered with galvanized jacket with high temperature aluminum paint. Provide 16inches x 16inches carbon steel insulated access door for inspection and cleaning.

G. Soot-blowers: Furnish economizer with one or more soot-blowers as required to obtain full coverage of heating surfaces. Install soot-blowers transverse to axis of finned tubes for lane blowing.

1. Provide manually operated soot-blowers.
2. Provide motor-operated soot-blowers with remote pushbutton control.

H. Drainage: Provide economizers that are completely drainable by gravity after installation.

I. Feedwater Control System: Provide feedwater corrosion control system to prevent cold-end corrosion of economizer, and to control exit gas temperatures. Design system to elevate entering water temperature to control exit gas temperature and tube metal temperature; and to automatically maintain or adjust feedwater temperature to provide corrosion protection under all boiler operating loads. Provide factory-assembled system consisting of the following:

1. Heat exchanger mounted on steel supporting skid.

2. Self-contained dual piloted tight shutoff temperature control valve with integral temperature adjustment to control flow of steam to preheater.

3. Feedwater preheater outlet water vapor tension thermostat with well and flexible armored tubing connected to temperature regulator. Install thermostat in preheater leaving water piping.

4. Exit gas temperature vapor tension thermostat with flexible armored tubing connected to temperature regulator. Install thermostat in exit flue gas duct.

## PART 3 - EXECUTION

### 3.1 INSPECTION:

A. Examine areas and conditions under which boiler accessories are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

### 3.2 INSTALLATION OF BOILER ACCESSORIES:

A. Install boiler accessories as indicated, in accordance with manufacturer's installation instructions, and with recognized industry practices, to ensure that boiler accessories comply with requirements and serve intended purposes. Comply with requirements of state and local boiler codes, applicable portions of ASME Boiler and Pressure Vessel Code, and applicable portions of ASME B31.1 or ASME B31.9.

B. Coordinate with other work as necessary to interface installation of boiler accessories with other components of heat generation systems.

### 3.3 BOILER VALVES:

A. Stop-and-Check Valves: Install as indicated on top of boiler steam nozzles. Install additional chain operated stop valve between stop-and-check valve and boiler header.

B. Y-Type Blowdown Valves: Install as indicated on blowdown piping. Connect discharge to blowdown separator. Install additional stop valve between blowdown valve and boiler.

3.4 SAFETY AND RELIEF VALVES:

A. Steam Safety Valves: Install as indicated on top of boilers. Pipe discharge to floor drain for low-pressure service. Pipe discharge to outdoors for high-pressure service, pipe drain outlets of drip pan elbow to floor drain. Pipe drain outlets of exhaust heads full size to floor drain or sewer.

B. Water Relief Valves: Install as indicated on top of boilers. Pipe discharge to floor drain.

3.5 BOILER BLOWDOWN SEPARATORS:

A. General: Install boiler blowdown separators as indicated, on concrete pad. Connect drain to sewer, and vent to outdoors. Connect boiler blowdown inlet piping, and cold water supply piping with shutoff valve, strainer, and temperature regulator valve. Install temperature regulator valve bulb and thermometer in thermometer wells in blowdown separator discharge.

3.6 BOILER ECONOMIZERS:

A. Install as indicated, and in accordance with manufacturer's installation instructions. Pipe header drains to floor drain.

3.7 FIELD QUALITY CONTROL:

A. Flush and clean boiler accessories upon completion of installation, and in accordance with manufacturer's installation instructions.

B. Hydrostatically test, if required, assembled boiler accessories and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.

**END OF SECTION 23 53 00**

# SECTION 23 54 00 - FORCED AIR FURNACES

PART 1 - GENERAL

1.1 WORK INCLUDED:

A. Forced air furnaces.

B. Refrigerant cooling coil and condenser.

C. Controls.

1.2 QUALITY ASSURANCE:

A. Conform to requirements of UL and applicable codes.

B. Cooling system tested and rated to ARI Standard 210.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for forced air furnace systems materials and products.

B. Submit shop drawings and product data in accordance with Section 23 05 00, showing dimensions, connections, arrangement, accessories, flue sizing recommendations and controls.

C. Submit manufacturer's installation instructions.

D. Submit manufacturer's descriptive literature, operating instructions, and maintenance and repair data.

E. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to compressed air equipment. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

G. Maintenance Data: Submit maintenance data and parts lists for compressed air systems materials and products. Include this data, product data, shop drawings, record drawings, and wiring diagrams in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 WARRANTY:

A. Provide 5-year parts warranty on heat exchangers.

B. Provide 5-year warranty on

compressors. PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Forced Air Furnaces:
   a. Rheem
   b. Fedders
   c. York
   d. Lennox
   e. Trane

2.2 TYPE:

A. Provide upflow or counterflow type (as shown on the drawings) with gas burner and electric refrigeration.

B. Provide self-contained, packaged, factory assembled, pre- wired unit consisting of cabinet, supply fan, heat exchanger, burner or heater, controls, air filter, refrigerant cooling coil and outdoor package containing compressor, condenser coil and condenser fan.

2.3 CONSTRUCTION:

A. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner and welded steel base.

B. Heat Exchanger: Cold rolled steel construction.

C. Burners shall be aluminized steel with crossover igniter of burner ports.

D. Supply Fan: Centrifugal type, rubber mounted with direct or belt drive, with adjustable variable pitch motor pulley or rubber isolated hinge mounted multispeed motor.

E. Air Filters: 1 inch (25 mm) thick glass fiber, disposable type arranged for easy replacement. Provide pleated type with 30 percent Eff. rating.

2.4 BURNER:

A. Gas Burner: Atmospheric or induced draft type with adjustable combustion air supply, equipped with combustion gas valve and pressure regulator incorporating manual shut- off, pilot valve, automatic 100 percent shut-off, and thermocouple pilot safety device. Provide with spark pilot ignition.

B. Gas Burner Safety Controls: Thermocouple sensor prevents opening of solenoid gas valve until pilot flame is proven and stops gas flow on ignition failure.

2.5 BURNER OPERATING CONTROLS:

A. Provide low voltage, adjustable room heating-cooling thermostats, to control burner operation to maintain room temperature settings.

B. Provide high limit control, with fixed stop at maximum permissible setting, to de-energize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.

C. Provide controls for supply fan in accordance with bonnet temperatures independent of burner controls. Include manual switch for continuous fan operation.

D. Provide safety interlock switch located in wiring junction box which shall automatically turn power off to unit when blower access panel is removed.

E. See drawing schedules for alternate options to be provided.

2.6 DRAFT CONTROL:

A. Provide each furnace with galvanized steel flue pipe having airtight joints.

B. For gas burner, provide furnace with draft diverter.

2.7 EVAPORATOR COIL:

A. Mount in furnace supply plenum copper tube aluminum fin coil assembly, with galvanized drain pan, 3/4inch drain connection, refrigerant piping connections. Provide with coil cabinet and adapter bases where required by manufacturer.

B. Provide factory installed thermostatic expansion valve kit including expansion and check valve.

2.8 REFRIGERATION PACKAGE:

A. Compressor: Hermetically sealed, 3600 rpm maximum, resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves, and drier.

B. Air Cooled Condenser: Aluminum fin and copper tube coil, direct drive propeller fan resiliently mounted, galvanized or PVC fan guard, mounting base.

C. Provide capacity ratings derived in accordance with ARI and DOE tests procedures. Provide certification of ARI on each unit. Provide units with UL listing.

D. Provide two-speed condenser where scheduled on drawings.

2.9 REFRIGERATION OPERATING CONTROLS:

A. Low voltage, adjustable thermostat controls compressor, condenser fan and supply fan to maintain room temperature setting. Provide remote return air temperature sensor behind return air grille in location shown.

B. Include thermostat system selector switch (heat-cool-off) and fan control switch (on-auto). Locate in corresponding mechanical room.

C. Timed off circuit shall limit number of compressor starts to 12 per hour.

D. Provide refrigerant pressure switch to cycle condenser fan. PART 3 EXECUTION

3.1 INSTALLATION:

A. Mount counterflow furnaces installed on combustible floors, on additive base.
B. Mount air cooled condenser package on concrete mounting pad. Pad by General Contractor.

**END OF SECTION 23 54 00**

# SECTION 23 62 00 - CONDENSING UNITS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK:

A. Section includes:

1. Residential air-cooled condensing units.
2. Air-cooled condensing units.
3. Water-cooled condensing units.

B. Manufacturers shall be responsible for providing to the contractor prior to bidding any information which may impact the installed cost for the contractor, including but not limited to:

1. Power wiring sizing, quantity and type of conductors and terminations requirements.
2. Control Power.
3. Auxiliary piping connections.

1.2 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants & environmentally friendly.

B. No CFC based refrigerants shall be used.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), dimensions, required clearances, and methods of assembly of components, furnished specialties and accessories; and installation and start-up instructions.

B. Wiring Diagrams: Submit ladder-type wiring diagrams for power and control wiring required for final installation of condensing units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

C. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Divisions 20 through 25.

D. Maintenance Data: Submit maintenance data and parts list for each condensing unit control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Operation and Maintenance Data: Submit maintenance data and parts list for each condensing unit, control, and accessory; including "trouble shooting" maintenance guide; plus servicing, and preventative maintenance procedures and schedule. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of condensing units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Capacity ratings for condensing units shall be in accordance with ARI Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment" and all other ARI standards applicable to the specific equipment as applicable.

2. Refrigeration system of condensing units shall be constructed in accordance with ASHRAE Standard ASHRAE 15 "Safety Code for Mechanical Refrigeration".

3. Condensing units shall meet or exceed the minimum COP/Efficiency levels as prescribed in ASHRAE 90A "Energy Conservation in New Building Design".

4. Construction and testing of water cooled condensing units shall be in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.

5. Condensing units shall be listed by UL and have UL label affixed.

6. Unit construction shall comply with ANSI safety codes.

7. Unit construction shall comply with the National Electrical Code.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handle condensing units and components carefully to prevent damage. Follow manufacturer's written instructions for rigging. Replace damaged condensing units or components.

B. Store condensing units and components in clean dry place off the ground. Protect from weather, water, and physical damage.

1.6 SPECIAL PROJECT WARRANTY:

A. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Extended Warranty Period: 5 years from date of substantial completion.

The extended warranty is only applicable when the Owner has requested and the associated costs have been determined, and it has been documented in writing. This is not applicable to residential and smaller tonnage units.

PART 2 – PRODUCTS

2.1 MANUFACTURERS:

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

1. Residential Air-Cooled Condensing Units:
   a. Air Conditioning; Div Corp.
   b. Lennox Industries, Inc.
   c. Trane (The) Co; Div American Standard Inc.
   d. York; Div York International.

2. Air-Cooled Condensing Units:
   a. McQuay Air Conditioning Group; McQuay Inc.
   b. Trane (The) Co; Div American Standard Inc.
   c. York; Div of York International.

3. Water-Cooled Condensing Units:
   a. McQuay Air Conditioning Group; McQuay Inc.
   b. Trane (The) Co; Div American Standard Inc.
   c. York; Div of York International.

2.2 RESIDENTIAL AIR-COOLED CONDENSING UNITS (1-1/2 TON TO 5 TONS):

A. General: Factory-assembled and tested air-cooled condensing units, consisting of compressor, condenser coil, fan, motor, refrigerant reservoir, and operating controls.

B. Casing: Galvanized steel finished with baked enamel, complete with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Unit shall be complete with brass service valves, fittings, and gauge ports on exterior of casing.

C. Compressor: Hermetically sealed, with built-in overloads and vibration isolation. Compressor motor shall have thermal and current sensitive overload devices, internal high-pressure protection, high and low pressure cutout switches, start capacitor and relay, 2-pole contactor, crankcase heater, and temperature actuated switch and timer to prevent compressor rapid cycle.

D. Condenser: Coil shall have copper tubes and aluminum fins, or aluminum tubes and aluminum fins; complete with liquid accumulator and liquid sub-cooler. Aluminum propeller fan shall be direct driven, with permanently lubricated fan motor having thermal overload protection.

1. Fan motor shall be 2-speed and shall automatically switch speeds.

E. The unit shall contain sufficient refrigerant charge for complete system.

F. Accessories:

1. Low-voltage thermostat and subbase to control condensing unit and evaporator fan.
   a. Low voltage control transformer.
   b. Start capacitor and relays.
   c. Indoor fan relays.

2. Precharged and insulated suction and liquid tubing of length indicated.
   a. Liquid line filter drier.

3. Heat reclaim device providing preheating of domestic hot water with hot gas from condensing unit.

4. Low-voltage control transformer.

5. Water-to-refrigerant heat exchanger.

6. Low ambient head pressure control.

7. Device to prevent compressor from short cycling.

2.3 AIR-COOLED CONDENSING UNITS:

Design Note: Provide electrical engineer the condensing unit manufacturer's starter wiring information.

A. General: Factory-assembled and tested air-cooled condensing units, consisting of casing, compressors, condensers, coils, condensing coil guard, condenser fans and motors, and unit controls.

B. Unit Casings: Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include:

1. Steel, galvanized or zinc-coated, for exposed casing surfaces, treated and finished with manufacturer's standard paint coating;

2. Lifting lugs to facilitate rigging of units;

3. Factory-installed metal grilles, for protection of condenser coil during shipping, installation, and operation;

4. Hinged and gasketed control panel door.

C. Compressor: Reciprocating hermetic-type compressor, 1,750 RPM, designed for air-cooled condensing, complete with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports. Capacity shall be controlled through cylinder unloading. Additional features include:

1. Crankcase heater in well within crankcase;
2. Capacity steps as scheduled, or greater number;
3. Compressor of same manufacturer as condensing unit.

Design Note: Specify reduced voltage starters for larger loads.

D. Controls: Operating and safety controls shall include high and low pressure cutouts, oil pressure cutout, compressor winding thermostat cutout, 3-leg compressor overload protection and condenser fan motors with thermal and overload cutouts. Control transformer if required shall be 115-volts. Provide magnetic contactors for compressor and condenser fan motors. Additional features include:

1. Reset relay circuit for manual resetting of cutouts from remote thermostat location;

2. Automatic nonrecycling pumpdown, and timing device to prevent excessive compressor cycling;

3. Unfused disconnect switch, factory-mounted and wired, for single external electrical power connection.

4. Compressor shall be located in a section separated from condenser fans and coils.

5. Compressor shall be mounted on spring isolators.

6. Compressor shall be provided with hot gas bypass

When HGBP is specified, make sure piping is shown on drawings. This is required when system capacity can be anticipated to drop to 30% or less. When in doubt, it should be provided.

7. Extended 5 year compressor warranty: 5 years from date of Final Completion and Acceptance.

E. Condensing Section: Condenser coil shall be seamless copper tubing mechanically bonded to heavy-duty, configurated aluminum fins, with separate and independent refrigeration circuit for

each compressor. Units shall include liquid accumulator and subcooling circuit, and backseating liquid line service access valve. Condenser coils shall be factory-tested at 450 psig, vacuum dehydrate, and filled with a holding charge of nitrogen.

F. Condenser fans and drives: propeller-type condenser fans for vertical air discharge; either direct drive or belt drive. Additional features include:

1. Permanent lubricated ball bearing condenser fan motors;
2. Separate motor for each condenser fan;
3. Constant speed condenser fan motors;
4. Each fan assembly shall be dynamically and statically balanced.

G. Low ambient head pressure control: Factory-installed low ambient damper assembly, fan speed control, or fan cycling control for operation down to -20 degrees F.

Design Note: Provide electrical engineer condensing unit manufacturers starter wiring information

2.4 WATER-COOLED CONDENSING UNITS:

A. General: Factory-assembled and tested water-cooled condensing units, consisting of reciprocating compressor, water-cooled condenser, base, and unit control panel.

B. Condenser: Multipass shell-and-tube type condenser having replaceable seamless integral finned copper tubes, positive liquid subcooling circuit, pressure relief device, liquid level test cock, purge connection, liquid line shutoff valve, and 1/4 inch flare angle valve for connection of water regulating valve.

1. Unit shall bear ASME stamp for refrigerant side working pressure of 385 psig and water side working pressure of 250 psig.

C. Compressor: Reciprocating serviceable hermetic type compressor with reversible oil pump, operating oil charge, and suction and discharge shutoff valves. Compressor shall be factory-mounted to base using spring isolators.

1. Compressor motor shall be using suction gas around motor windings. Thermally protect compressor motor.

2. Compressor shall be equipped with insert type crankcase heater of size required to control oil dilution during shutdown.

3. Capacity control shall be obtained through cylinder unloading, by suction pressure controlled and discharge pressure operated. Design so compressor will start with controlled cylinders unloaded.

4. Compressor shall be located in a section separated from condenser fans and coils.

5. Compressor shall be mounted on spring isolators.

6. Compressor shall be provided wit hot gas bypass

7. Extended 5 year compressor warranty: 5 years from date of substantial completion.

8. Compressor speed shall not exceed 1750 rpm.

Design Note: Specify reduced voltage starter for larger loads sizes.

D. Controls: factory-mounted and wired control panel containing the following:

1. Positive acting timer to prevent short cycling;
2. High and low pressure controls;
3. Power and control circuit terminal blocks;
4. Compressor motor starter;
5. Control relays;
6. Control circuit off-on switch;
7. Control circuit fuse.

E. Accessories:

1. Discharge line muffler;
2. Gauge panel containing gauges for suction, discharge, and oil pressure;
3. Electric solenoid unloading in lieu of suction-pressure unloading;
4. Control circuit transformer; line to 130-volts AC;
5. Pumpdown relay package;
6. Crankcase coverplates with equalizer connections.
7. Combination sight glass and moisture indicator.
8. Refrigerant filter/dryer.
9. Charging valve.
10. Insulation on all suction lines.

F. Low ambient head pressure control: Factory installed low ambient damper assembly, fan speed control or fan cycling control for operation down to -20 degrees F.

## PART 3 - EXECUTION

### 3.1 EXAMINATION:

A. Verify roof structure, mounting supports, and membrane installations are completed to the proper point to allow installation of roof mounted units. Do not proceed with work until unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION:

A. General: Install condensing units in accordance with manufacturers installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

1. Provide flexible connections on all piping connections.

B. Install ground-mounted units on 4inch thick reinforced concrete pad, 4inches larger on each side than condensing unit. Concrete is specified in Division 3. Coordinate installation of anchoring devices.

C. Install roof-mounted units on equipment supports on roof curbs with water proof flashing. Anchor unit to supports with removable fasteners.

D. Residential Units: Connect pre-charged refrigerant tubing to unit's quick-connect fittings. Run tubing so as not to interfere with access to unit.

1. Install furnished accessories.

E. Air-Cooled Condensing Units: Connect refrigerant piping to unit; maintain required access to unit.

1. Install furnished field-mounted accessories.

F. Water-Cooled Condensing Units: Connect refrigerant piping to unit and condenser water piping. Maintain clear tube removal space.

## 3.3 FIELD QUALITY CONTROL:

A. Testing: Test unit when field piping is completed through all phases of operation after pressure tests have been completed in compliance with Section 23 05 93 specification.

B. Charge systems will full charge of refrigerant and oil, and test for leaks. Repair leaks, and replace lost refrigerant and oil.

1. Install core in filter dryer after leak test, but before evacuation.

2. Evacuate refrigerant system with vacuum pump until 35 degrees F is indicated on vacuum dehydration gauge.

## 3.4 DEMONSTRATION:

A. Provide services of manufacturer's authorized service representative to provide factory start-up service and to instruct Owner's personnel in operation and maintenance of condensing units.

B. Start-up condensing units, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

C. Train Owner's personnel on start-up and shut-down procedures, troubleshooting procedures, servicing, and preventative maintenance schedule and procedures. Review with the Owner's personnel the data contained in the Operating and Maintenance Manuals specified in this section and the LPS General Conditions of the Contract.

## 3.5 TRAINING:

A. Schedule a minimum of 4 hours of training with Owner. The manufacturer’s representative and the installing contractor shall be present. The training shall be coordinated by the installing contractor, General Contractor, Architect/Engineer and the Owner in conjunction with the other mechanical equipment on the project.

B. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

2. Schedule training with Owner through the Architect/Engineer with at least 7 days’ prior notice.

**END OF SECTION 23 62 00**

# SECTION 23 63 13 - AIR COOLED CONDENSERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This Section includes

1. Air cooled condensers.

B. Refer to other Divisions 20 through 25 sections for piping, vibration controls, temperature control; not work of this section.

C. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on condensers. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
2. Interlock wiring between condensers and between condensers and field-installed control devices.
   a. Interlock wiring specified as factory-installed is work of this section.

D. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and condensers control panels.
   a. Control wiring specified as work of Section 23 09 23 for Automatic Temperature Controls is work of that section.

1.2 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants & environmentally friendly.

B. No CFC-based refrigerants shall be used.

1.3 SUBMITTALS:

A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. The equipment provided shall provide the scheduled capacity when the substitute refrigerant proposed, the nominal equipment capacity reduction effects (if any), performance in KW/TON, the refrigerant change out procedure and long-term maintenance affects the new refrigerant has on the equipment.

B. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.

C. Shop Drawings: Submit shop drawings detailing dimensions, required clearances, methods of assembly of components, and mounting and connection details.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions that must be field installed.

E. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

F. Maintenance Data: Submit maintenance data and parts list for each air cooled condenser, control and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements the LPS General Conditions of the Contract and Divisions 20 through 25.

G. Quality Control Submittals:

1. Submit certification of compliance with specified ARI, UL, AND ASHRAE fabrication requirements.
2. Submit certification of compliance with performance verification requirements specified in Part 2 of this Section.

1.4 QUALITY ASSURANCE:

A. Codes and Standards:

1. Capacity ratings shall be in accordance with ARI Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment" and all other ARI standards applicable.
2. Refrigeration system shall be constructed in accordance with ASHRAE Standard ASHRAE 15 "Safety Code for Mechanical Refrigeration".
3. Air cooled Condensers shall meet or exceed the minimum COP/Efficiency levels as prescribed in ASHRAE 90A "Energy Conservation in New Building Design".
4. Air cooled Condensers shall be listed by UL and have UL label affixed.
5. Unit construction shall comply with ANSI safety code.
6. Unit construction shall comply with the National Electrical Code.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Follow manufacturer's written instructions for rigging.

1.6 SEQUENCING AND SCHEDULING:

A. Coordinate layout of roof-mounted equipment supports and roof penetrations for roof-mounted units.

B. Coordinate size and location at concrete equipment bases for ground mounted units.

C. Coordinate rough-in of refrigerant piping and electrical service.

1.7 SPECIAL PROJECT WARRANTY:

A. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate or defective materials and/or workmanship, including leakage, breakage, improper assembly or failure to perform as required, provided that manufacturer's instructions for handling, installing, protecting,\ and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only and does not include labor for removal and reinstallation.

B. Warranty Period: 5 years from Date of Final Completion and Acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Air Cooled Condensers :
   a. McQuay Air Conditioning Group; McQuay Inc.
   b. Trane (The) Co; Div American Standard Inc.
   c. York; Div of York International.

B. General: Factory-assembled and tested, air cooled condensers, consisting of casing, condensers coils, condenser fans and motors, and unit controls. Capacities and electrical characteristics are scheduled at the end of this Section.

C. Unit Casings: designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to controls, condenser fans, motors, and drives. Additional features include:

1. Steel, galvanized or zinc-coated, for exposed casing surfaces, treated and finished with manufacturer's standard paint coating;
2. Lifting lugs to facilitate rigging of units;
3. Factory-installed metal grilles, for protection of condenser coil during shipping, installation, and operation;
4. Hinged and gasketed control panel door.
5. Roof mounted units shall be mounted on spring isolators.

D. Controls: Operating and safety controls shall include condenser fan motors thermal and overload cutouts. Control transformer if required shall be as required by the Section 23 09 23 controls contractor. Provide magnetic contactors for condenser fan motors, and an unfused disconnect switch which is factory-mounted and wired for single external electrical power connection.

E. Condensing Section: Condenser coil shall be seamless copper tubing mechanically bonded to heavy-duty, configurated aluminum fins. Units shall include liquid accumulator and subcooling circuit, and back-seating liquid line service access valve. Condenser coils shall be factory tested at 450 psig, vacuum dehydrate, and filled with a holding charge of nitrogen. Additional features include:

1. Insulated receivers.
2. Pressure relief valves.
3. Head pressure control valves.

F. Condenser fans and drives: Propeller-type condenser fans for vertical air discharge; either direct drive or belt drive. Additional features include:

1. Permanent lubricated ball bearing condenser fan motors;
2. Separate motor for each condenser fan;
3. Constant speed condenser fan motors;
4. Each fan assembly dynamically and statically balanced.

G. Low ambient head pressure control: Factory-installed low ambient damper assembly, fan speed control, or fan cycling control for operation down to -20 [ ] degrees F.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Verify all dimensions by field measurements. Verify that all air cooled condensers may be installed in accordance with pertinent codes and regulations, the original design, and referenced standards.

B. Verify roof structure, mounting supports, and membrane installations are completed to the proper point to allow installation of roof mounted units.

C. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION:

A. Install air cooled condensers in accordance with manufacturer’s installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Install ground-mounted units on 4" thick reinforced concrete pad, 4" larger on each side than condensing unit. Concrete, formwork, and reinforcing are specified in Division 3. Coordinate installation of anchoring devices.

C. Install roof-mounted units on equipment supports specified in Division 7. Anchor unit to supports with removable fasteners.

D. Install furnished field mounted accessories.

3.3 CONNECTIONS:

A. The Drawings indicate the general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow servicing and maintenance.

1. Provide flexible connections on all piping connections.

3.4 FIELD QUALITY CONTROL:

A. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.

B. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.

3.5 DEMONSTRATION:

A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.

B. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

C. Training:

1. Schedule a minimum of 4 hours of training with Owner. The manufacturer's representative and the installing contractor shall be present. The training shall be coordinated by the installing contractor, General Contractor, Architect/Engineer and the Owner in conjunction with the other mechanical equipment on the project.
2. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

**END OF SECTION 23 63 13**

# SECTION 23 64 16.13 - CENTRIFUGAL CHILLERS - AIR COOLED

PART 1 - GENERAL

1.1 SUMMARY:

A. This Section specifies packaged, air cooled, hermetic centrifugal water chillers.

B. This Section specifies the installation requirements for the Owner furnished centrifugal water chillers. Refer to LPS General Conditions of the Contract and other sections of Divisions 20 through 25 for requirements for Owner-furnished equipment.

1.2 SUBMITTALS:

A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. The equipment provided shall provide the scheduled capacity when the substitute refrigerant is used. Each company shall identify the substitute refrigerant proposed, the nominal equipment capacity reduction effects, (if any), performance in KW/TON, the refrigerant change out procedure and long term maintenance effects the new refrigerant has on the equipment.

B. Product Data: Submit product data, including rated capacities, weights (shipping, installed, and operating), furnished specialties and accessories; and installation and start-up instructions.

C. Shop Drawings: Submit manufacturer's assembly type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field connection.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

F. Maintenance Data: Submit maintenance data and parts list for each centrifugal chiller, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and other sections of Divisions 20 through 25.

G. Quality Control Submittals:

1. Submit certification of compliance with ASME, UL, AND ASHRAE fabrication requirements specified in Quality Assurance below.
2. Submit certification of compliance with performance verification requirements specified in Part 2 of this Section.
3. Submit quality control reports specified in Part 3 of this Section.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of centrifugal chillers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Machine Experience: At time of submission of bid or proposal, chiller model proposed must have acquired minimum of 2 years' experience on each of 10 field installations, each machine having acquired minimum of 2,400 operating hours.

C. Regulatory Requirements:

1. ASHRAE Compliance: Fabricate and install centrifugal chillers to comply with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
2. UL Compliance: fabricate centrifugal chillers to comply with UL 465 "Central Cooling Air Conditioners".
3. ASME Compliance: fabricate and stamp centrifugal chillers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Deliver chillers as a complete factory assembled unit with protective crating and covering.

B. Ship chillers in a deep vacuum in one of two pieces, depending upon size.

C. Store, on site, in a dry/clean environment or properly covered until the equipment is put into operation.

1.5 SEQUENCING AND SCHEDULING:

A. Coordinate the size and location of concrete equipment pads for on-grade installations. Cast anchor bolt inserts into pad.

B. Coordinate the installation of roof curbs and equipment supports, and roof penetrations.

C. Concrete, reinforcement, and formwork requirements are specified in Division 3.

D. Roof specialties are specified in Division 7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Centrifugal Chillers:
   a. The Trane Co.
   b. Carrier
   c. McQuay
   d. York

2.2 UNIT DESCRIPTION:

A. Packaged, factory-assembled, piped, wired, and charged hermetic type centrifugal chillers consisting of centrifugal compressor, compressor motor, motor starter, evaporator, air cooled condenser, weather-tight equipment enclosure, controls and panels including gages and indicating lights, auxiliary components, and accessories.

B. Provide auxiliary condensers of capacity scheduled for heat-recovery units.

2.3 COMPONENTS:

A. A. Compressor:

1. Shaft and Impeller Assembly: carbon or forged steel shaft with cast high-strength aluminum alloy impellers, designed and assembled for no critical speeds within operating range; and statically and dynamically balanced.
2. Casing: fine grain cast iron with gasket sealed casing joints.
3. Drive Assembly: gear transmission integral with compressor and lubricated through compressor lubrication system.
    a. Gear Assembly: gears and journal bearings Babbitt-lined and pressure lubricated; provide inspection openings, to facilitate bearing inspection and replacement without disassembly or removal of compressor casing or impeller.
4. Lubrication System: forced circulation type, with positive displacement submerged pump and replaceable oil filter; complete with an automatic oil heater designed to separate refrigerant from oil, and oil cooler if required for proper performance. System shall provide positive pressure lubrication of journals, bearings and seals (if any), during start-up, operation, and coast-down of chiller, including power interruptions. On two compressor units provide redundant oil pump.
5. Motor and Accessories: hermetically sealed, continuous duty, single speed, squirrel cage, induction type; full load operation of the motor shall not exceed nameplate rating; rotor shaft shall be heat treated carbon steel and designed such that the first critical speed is well above the operating speed. Provide for removal of the stator for service or replacement without breaking the main refrigerant piping connections.
6. Compressor Motor Starters: Provide factory mounted and wired starters. Starters shall be a star-delta closed transition type, of sizes, ratings, and electrical characteristics scheduled; with a NEMA 1 enclosure. Provide starters with an electronic protection system to monitor and protect against three-phase overload, overload during starting, phase unbalance, and over and under voltage. Field wiring and electrical connections are specified in Division 26.

B. Evaporator:

1. Shell and Water Boxes: fabricated from welded carbon steel plate. Provide 150 psig maximum working pressure water boxes and nozzle connections. Provide suitable tappings in the water boxes and nozzles for control sensors, gages, and thermometers.
2. Water Heads: fabricated steel water heads with integral water connections.
3. Tube Sheets: fabricated of thick carbon steel sheets welded to the shell and drilled for tubes. Include intermediate tube support sheets as required to prevent tube vibration.

4. Tubes: individually replaceable, finned, seamless copper tubes; removable from either end of the heat exchanger without affection strength and durability of the tube sheets and without causing leakage in adjacent tubes. Expand ends of tubes in tube sheets and intermediate tube support sheets for tight fit to prevent vibration of tubes. Provide suitable baffles or distributing plates in condenser tubes to evenly distribute refrigerant discharge gas on heat transfer tubes.
5. Pressure Limiting and Pressure Relief Devices: Manufacturer's standard complying with ASHRAE 15.

C. Condenser:

1. Coil: Aluminum fin mechanically bonded to 5/8 inch OD seamless copper tubing. Subcooler circuit, standard. Factory tested to 375 psig air-under-water.
2. Fan and Motor: vertical discharge, low speed, belt driven, propeller type fans; cycle to maintain head pressure. Form orifices to allow close tip clearance.

D. Auxiliary Condenser:

1. Shell and Water Boxes: fabricated from welded carbon steel plate. Provide 150 psig maximum working pressure water boxes and nozzle connections. Provide suitable tappings in the water boxes and nozzles for control sensors, gages, and thermometers.
2. Water Heads: fabricated steel water heads with integral water connections.

2.4 ACCESSORIES:

A. Purge System: designed to evacuate non-condensable gases and water vapor from the system and for condensing, separating, and returning refrigerant to the system. Provide all necessary devices to automatically isolate purge system from chiller.

2.5 CONTROLS AND SAFETIES:

A. Refrigerant Flow Control Devices:

1. Provide refrigerant flow control devices between evaporator and condensers (and elsewhere as required) to regulate refrigerant flow at volume and pressure required to maintain evaporator liquid refrigerant at level sufficient to keep cooler heat transfer tubes adequately wetted through full range of chiller operation.
2. Design devices to permit chiller operation at scheduled conditions, and to allow condenser entering water temperature to decrease to minimum permissible temperature or 1 deg. F (0.5 deg. C) above return chilled water temperature.

B. Capacity Control:

1. Designed and fabricated to regulate evaporator leaving water temperature. Design for capacity modulation, from full load to scheduled minimum load capacity under normal operating conditions, without overshooting and without hunting at scheduled throttling range.
2. Provide variable guide vanes to provide stable operation without surge, cavitation, or vibration from 100 to 10 percent of full load capacity, without hot-gas bypass.
3. Provide diffuser blocks, designed to operate at part load condition to minimize part load stall, to maintain compressor stability at any load condition.

C. Safety Controls:

1. Design cutouts to operate independently and factory wire to control panel. Design controls to stop compressor motor in event of low refrigerant pressure or temperature in evaporator; high condenser pressure, high compressor discharge temperature, low evaporator leaving water temperature (freeze-stat), high motor temperature, high bearing temperature, low oil pressure, high oil temperature, compressor motor overcurrent or over voltage, or power interruption. Design each cutout to require manual re-starting of compressor.
2. Include anti-recycle timer, factory wired to control panel, limiting compressor motor restarts at scheduled time intervals.

D. Operational Controls:

1. Provide controls to ensure that compressor will start only under unloaded condition.
2. Provide sequencing controls to ensure lubrication of compressor motor bearings and seals (if any). Sequence as follows:
   a. Run lubrication system oil so that compressor motor bearing is lubricated before startup,
   b. Start compressor motor,
   c. Provide lubrication during coast-down after compressor motor shutdown.
3. Provide modular electronic, solid state or (if the building's existing control system allows and if pre-approved by the LPS Operations, Maintenance and Construction (OMC) Department) pneumatic controls.
4. Design controls to automatically restart compressor after power failure interruptions, provided minimum time between starts has been compiled with.

E. Diagnostics: Provide a diagnostic module capable of indicating all lockout conditions specified above, plus recording the elapsed time (pre-alarm to alarm), the operating conditions of the compressor motor (amperes), refrigerant temperatures and pressures, and chilled and condenser water temperatures (entering and leaving) at the time of lockout.

F. Control Panel:

1. Factory-mounted and wired. Provide gages or meters to indicate low refrigerant pressure in evaporator, high condenser pressure, and low oil pressure.
2. Provide switches and push-buttons designed to permit indicated operations including the following:
   a. Manual and automatic operation of oil pump.
   b. Manual and automatic operation of oil separator heater.
3. Provide pilot lights or visual flag switches for indicated operations and cutouts including the following:
   a. Oil pump operation.
   b. Low chilled water temperature cutout.
   c. Low water flow cutout.
   d. Oil separator heater operation.
   e. Low evaporator refrigerant pressure or temperature cutout.
   f. High condenser pressure cutout.
   g. High motor winding temperature cutout.
   h. Low oil pressure cutout.

i. Motor overload cutout.

4. Provide elapsed time meter designed to automatically record total chiller operating time, in hours.

5. Provide electrical interlock to prevent chiller operation when chilled water pump is not operating.

2.6 INSULATION:

A. Insulate evaporators and other cold surfaces to prevent condensation, with ambient humidity of 75 percent and dry-bulb temperature of 90 deg. F (32 deg. C), no air movement. Use manufacturer's standard insulation material.

2.7 EQUIPMENT ENCLOSURE:

A. All components except air cooled condenser and starter shall be housed in a weather-tight insulated metal equipment enclosure to protect equipment and provide tempered environment for service. All starters and disconnects shall be located in their own separate, weather-tight enclosure. Lighted equipment enclosure shall have a 120-volt convenience outlet and electric unit heater for freeze protection to -20 deg. F ambient. High ambient units shall have a fan-coil unit instead of a unit heater. All enclosures shall be galvanized steel with factory finish.

2.8 FACTORY FINISH:

A. Chiller manufacturer's standard factory finish.

2.9 SOURCE QUALITY CONTROL:

A. Test and Inspect: centrifugal chillers in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

B. B. Performance Verification:

1. Rate centrifugal chillers in accordance with ARI 550 "Standard for Centrifugal or Rotary Water-Chilling Packages".

2. Provide a Coefficient Of Performance (COP) for centrifugal chillers not less than prescribed by ASHRAE 90A "Energy Conservation in New Building Design".

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install chillers in accordance with manufacturer’s installation instructions.

B. Install chillers plumb and level, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.

C. Coordinate installation of roof curbs and equipment supports, and required roof penetrations.

3.2 PIPING CONNECTIONS:

A. Piping installation requirements are specified in other sections of Divisions 20 through 23. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to machine to allow servicing and maintenance.
2. Chilled Water Piping: Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, thermometer, pressure gage, and union or flange.
3. Auxiliary Condenser: Provide bypass valve to bypass water flow around auxiliary condenser when centrifugal chiller compressor is not operating.

3.3 FIELD QUALITY CONTROL:

A. Provide the services, to include a written report, of a factory authorized service representative to supervise the field assembly of the components, installation, and piping and electrical connections.

3.4 3.4 DEMONSTRATION:

A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.

B. Start-up Service:

1. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.
3. Do not place chillers in sustained operation prior to initial balancing of mechanical systems for interface with chillers.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the data contained in the Operating and Maintenance Manuals specified in PART 1 of this Section and in the LPS General Conditions of the Contract and other sections of Divisions 20 through 25.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days' prior notice.

**END OF SECTION 23 64 16.13**

# SECTION 23 64 16.16 - CENTRIFUGAL CHILLERS - WATER COOLED

PART 1 - GENERAL

1.1 WORK INCLUDED:

A. Centrifugal water cooled chillers.

B. Controls and control panel.

C. Manufacturers shall be responsible for providing to the contractor prior to bidding any information which may impact the installed cost for the contractor including but not limited to:

1. Power wiring sizing quantity and type of conductors.
2. Control power.
3. Auxiliary piping connections.

1.2 BIDDING REQUIREMENTS:

Include life cycle cost form when applicable.

A. Manufacturer's bid shall include a completed life cycle cost analysis form based on the criteria following at the end of this section.

B. Provide KW/Ton versus percent of load graph with bid submittal.

C. Proposal shall include fabrication and delivery schedule.

D. If disassembling and reassembly is required, that cost shall be a part of this bid.

1.3 REFERENCES AND REGULATORY REQUIREMENTS:

A. ANSI/ASHRAE Standard 15-1994 - Safety Code for Mechanical Refrigeration, with all currently adopted amendments.

B. ANSI/ASHRAE 90.1-1989 - Energy Efficiency of New Non-Residential and High Rise Residential Buildings.

C. ASME Section VIII - Boiler and Pressure Vessel Code.

D. ANSI/UL 465 - Central Cooling Air Conditioners.

E. ARI Standard 550/590-98 - a: Provide UL label. Centrifugal or Rotary Water Chilling Packages.

F. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings. Bearings must have life of not less than 200,000 hours.

1.4 SUBMITTALS:

A. Submit product data, shop drawings, and wiring diagrams in accordance with Section 23 05 00.

B. Quality Control Submittals: Submit certification of compliance with ASME, UL, AND ASHRAE fabrication requirements. Submit proof of manufacturer's qualifications and machine experience specified in Quality Assurance below.

C. Test Results: Submit results of all factory tests specified below.

1.5 VERIFICATION OF CAPACITY AND EFFICIENCY:

A. Each chiller shall be factory performance tested under full load conditions in an ARI certified test facility. The manufacturer shall supply a certified test report to confirm performance as specified. Proper ARI certification documents for the test loop shall be made available upon request from the manufacturer for inspection. The performance test shall be conducted in accordance with ARI Standard 550/590-98 procedures and tolerances.

B. All proposals for chiller performance shall include an ARI approved selection method. Verification of date and version of computer program selection or catalog is available through the ARI.

C. The performance test shall be run with clean tubes in accordance with ARI 550/590-98.

D. The factory test instrumentation shall be per ARI Standard 500, and the calibration of all instrumentation shall be traceable to the National Institute of Standards and Technology.

Use paragraph E only if a witness test is required.

E. The Owner or his representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his representative desires to witness the performance test, all travel, lodging and meal costs will be the manufacturer's responsibility.

F. A certified test report of all data shall be submitted to the Engineer prior to completion of the project. The factory certified test report shall be signed by an authorized representative of the manufacturer's company. Preprinted certification will not be acceptable; certification shall be in the original.

Edit the following carefully, penalty and/or rejection of equipment.

G. The equipment will be accepted if the test procedures and results are in conformance with ARI Standard 550/590-98. If the equipment fails to perform within allowable tolerances, the manufacturer will be allowed to make necessary revisions to his equipment and retest as required. The manufacturer shall assume all expenses incurred by the Owner or his representative to witness the retest. In the event that these revisions do not achieve submitted performance, the following penalties will be imposed.

1. CAPACITY TEST: For each ton below the allowable capacity as set forth in ARI 550/590-98 of the design capacity, five hundred dollars per ton will be deducted from the contract price.

   Allowable capacity = (1 - tolerance) x design capacity; tolerance per ARI 550-90, Section 5.4.

2. POWER CONSUMPTION TEST: The power consumption penalty for all load points shall be based upon the tolerances set forth in ARI 550/590-98 The power consumption penalty (P.C.P.) will be calculated based upon the following formula:

   P.C.P. = Measured KW - (Measured Tons x Allowable KW/Ton*) x $1000/KW

*Allowable KW/Ton = (1 + tolerance) x design KW/Ton; to tolerance per ARI 550/590- 98, Section 5.4.

3. TOTAL PERFORMANCE PENALTY: The total performance penalty will be the sum of CAPACITY PENALTY AND POWER CONSUMPTION PENALTY, times the number of typical chillers, regardless if tested.

H. Equipment manufacturer shall not ship the centrifugal chiller(s) until successful completion of the performance test or Owner's acceptance of penalty deduction from the contract.

1.6 SOUND:

A. Sound Data: The Centrifugal Chiller Sound Pressure Level (SPL), in decibels (dB), with a reference pressure of 20 micropascals, shall not exceed the values listed in "a" below. All rating shall be in accordance with ARI Standard 575-87, "Method of Measuring Machinery Sound Within Equipment Rooms."

EDIT NOTE: Include 1. if system design includes constant condenser water temperature or 2. if condenser water temperature will be lowered at part load.

1. The Owner or his representative shall be notified 14 days in advance to witness the factory performance test. If the Owner or his representative desires to witness the performance test, all travel, lodging and meal costs will be the manufacturer's responsibility.

2. Condenser water temperature may be reduced at part load conditions as allowed by ARI 550/590.

EDIT NOTE: Engineer to complete. Either leave values in Table a. or have manufacturer's representative provide if lower sound is required.

a. Allowable Sound Levels:

| % Load | dB, A Weighted |
|---|---|
| 100 | 87 |
| 50 | 90 |
| 25 | 90 |

B. Sound Pressure Test: The chiller (one of each size) shall have a sound test conducted at the factory prior to shipment to confirm the Sound Pressure Levels submitted in Section 3.1.A. above. All data must be measured and presented in strict accordance with ARI Standard 575-87.

If a witness test is required, use paragraphs 1 and 4.

1. The Project Engineer or his representative must be present to witness the test.

2. In the event that a chiller does not meet the submitted dBA sound pressure level, the manufacturer must, at his expense, provide sufficient attenuation to the machine to meet the submitted value. This attenuation shall be applied in such a manner that it does not hinder the operation or routine maintenance procedures of the chiller.

3. If the unit cannot be modified to meet the submitted SPL levels, sufficient funds will be deducted from the purchase order to cover materials and labor for jobsite attenuation to bring the sound levels to an acceptable level.

4. The Project Engineer or his representative must witness the test after attenuation to confirm that the submitted values are met. The manufacturer will assume all expenses incurred by the project engineer or his representative to witness the retest.

1.7 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of centrifugal chillers of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Machine Experience: At time of submission of bid or proposal, chiller model proposed must have acquired minimum of 2 years' experience on each of 10 field installations, each machine having acquired minimum of 2,400 operating hours.

1.8 DELIVERY, STORAGE, AND HANDLING:

A. Deliver chillers as a complete factory-assembled unit with protective crating and covering.

B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting unit.

C. Ship chillers charged, or with a nitrogen holding charge in one or two pieces, depending upon size.

D. Coordinate the delivery of the chiller(s) in sufficient time to allow movement into the building.

E. Store, on site, in a dry/clean environment. Protect chiller(s) from physical damage. Leave factory shipping covers in place until installation is complete.

F. Additional Refrigerant: Coordinate delivery of refrigerant to the site with Contractor in charge. Store in a dry/clean environment until storage room of building is complete.

1.9 SEQUENCING AND SCHEDULING:

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

B. Concrete, reinforcement, and formwork requirements are specified in Division 3.

Coordinate warranty time duration with the Owner. Get budget pricing from manufacturer's representative.

1.10 WARRANTY:

A. Provide_____year warranty including all parts, labor, materials, transportation and shipping charges with no cost to the Owner. All compressors motors, driveline and shaft seals shall have a minimum warranty period of 2 / 5 years for all parts and labor (at no cost to the Owner).

B. Warranty shall not begin until the Owner has accepted the temperature control system.

Include maintenance service if Owner requests. This is normally not specified.

1.11 MAINTENANCE SERVICE:

A. Furnish service and maintenance of chillers immediately after Final Completion and Acceptance for a period of [ ] years including all parts, labor and miscellaneous costs. Maintenance shall include all service indicated in the operation and maintenance manual over the time period indicated above. In addition to the manufacturer's recommendations, provide the following annual service:

1. Oil Analysis - change as required.
2. Clean tubes.
3. Full driveline inspection - report only.
   (Service falls under warranty period above)
4. Megger Test, motor - report only.
   (Service falls under warranty period above)

PART 2 - PRODUCTS

2.1 SUMMARY:

A. The contractor shall furnish and install centrifugal water chillers as shown and scheduled in the plans. The units shall be installed in accordance with this specification and produce the specified tonnage per the scheduled data in accordance with ARI 550/590-98. The unit shall bear the ARI certification label as applicable.

2.2 MANUFACTURERS:

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

1. Centrifugal Chillers:
   a. Carrier
   b. McQuay
   c. Trane Co.
   d. A/C Group
   e. York Int'l.

B. Chiller shall be a complete factory package including a centrifugal compressor, open or hermetically sealed motor, compressor motor starter, cooler, condenser, purge unit. Unit shall be factory assembled, piped, wired, leak tested and painted with a minimum of two coats of primer paint and two coats of finish paint.

2.3 REFRIGERANT:

A. The following refrigerants are acceptable:
1. R-22
2. R-123
3. R-134a

2.4 COMPRESSOR AND MOTOR:

A. The compressor shall be centrifugal.

B. The compressor shall have an impeller wheel of cast high strength aluminum alloy. The shaft bearings shall have forced feed lubrication. The variable inlet vane guide at the compressor inlet shall provide capacity modulation of 100% of 10% of design load with $4^{o}$F reduction in entering condenser water temperature per 10% reduction in capacity per ARI Standard 550/590-98. This shall be accomplished at constant full load water flow rates by varying the volume of gas handled by the compressor. The guide vanes shall be operated by the refrigeration load on the evaporator. Impeller (s) shall be dynamically balanced and tested at a minimum of 4500 RPM.

C. Compressor assembly shall be run-tested at the factory. Vibration shall not exceed 1.0 mil peak to peak.

EDIT NOTE: Design of chiller room may be affected by open vs. hermetic motor. Consider motor heat and room cooling. If significant, spell out alternate designs on drawings.

D. Hermetic Motors (Trane, _____):

1. Motors shall be refrigerant cooled, single speed, hermetically sealed, squirrel cage induction type.

2. Motor shall be assembled for each service and removal without breaking the main refrigerant piping connections.

3. Motor shall be suitable for 60 hertz, three phase power.

E. Open Drive Motors (York, _____):

1. Motors shall be open drip proof, single speed, squirrel cage, induction type.

2. Motors shall be rigidly coupled to the compressor. Provide factory alignment of motors and compressor shafts.

3. Motor shall be assembled to allow access for repair or removal without removing the refrigerant charge from chiller.

4. Provide a motor-compressor shaft seal leakage containment system.

5. Motor shall be suitable for 60 hertz, three phase power.

F. The lubrication system shall be of the force feed type with an oil pump supplying oil under pressure to all bearings, gears, and rotating surfaces. The oil pump shall be external to the compressor. The lubrication system shall provide a positive supply of oil to all bearings even during a power failure shutdown to the compressor. A replaceable external oil filter with provisions for servicing without removing the unit refrigerant charge shall be provided. A refrigerant or water cooled oil cooler shall be provided. Heater shall be furnished in the oil reservoir. Complete lubrication system shall be factory installed and piped. Provisions shall be made within the control panel to furnish power for the oil pump, heater and oil cooler without the necessity of an additional external electrical connection(s).

G. Provide a rupture disk and a re-seatable relief valve for low-pressure (R-123) chillers. Provide a relief valve for all high pressure chillers (R-134a, R-22).

Edit for appropriate pressures and pipe connections.

## 2.5 EVAPORATOR AND CONDENSER:

A. The evaporator and condenser shall be built in accordance with ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration, ASME Code construction and stamped. Water boxes shall be designed for 300/150 PSIG maximum working pressure. The water piping connections shall be flanged.

B. Water velocity through evaporator and condensers tubes shall not exceed 8 feet per second.

Choose one of the following C and D Paragraphs

C. Evaporator and Condenser tube. Nominal tube wall thickness shall be minimum 0.025 inches.

D. Supply and return head water boxes shall be designed for a working pressure of 150/300 psig and shall be subjected to a factory hydrostatic pressure test of 225/450 psig. Provide drain and vent connections in water boxes.

Use marine water boxes where required; they normally are not used on most projects. They are used for ease of tube cleaning typically in the condenser only.

E. Marine water boxes with side connections for the evaporator and condenser shall be provided such that the water piping of both the entering and leaving sides need not be disconnected for mechanical cleaning. The water piping connections shall be in a direction perpendicular to the shells to allow full unblocked access to the tubes

F. Factory insulation shall be 3/4" or 1-1/2" elastomeric foam insulation (max. k=.28 BTU/ft - HR) and cover all low temperature surfaces to include the evaporator and water boxes, suction elbow, economizer and motor cooling lines.

G. Provide factory installed refrigerant sight glass.

EDIT NOTE: Verify need for epoxy coating at 15K adder +/-.

H. Provide factory applied epoxy coating for condenser/and evaporator tube sheet(s) and all four/both water box heads.

I. Provide lifting eye hooks on all four water boxes for maintenance.

J. Cooler shall contain integral mist eliminators to prevent carryover of liquid refrigerant into compressor suction.

K. Provide factory supplied refrigerant and oil shipped to job site ready for installation by factory authorized representative.

## 2.6 PURGE SYSTEM:

A. The manufacturer of low pressure machines must provide a separate compressor type purge system providing positive means of collection, return of refrigerant and removal of non-condensables. No external water cooling source is to be required.

B. The purge unit shall include necessary operating controls, piping, and refrigerant service valves to isolate the purge unit from the chilling unit. The purge unit shall be completely factory mounted, piped and wired.

C. Any excess purge requirement will enable a fault indication light at the purge and a contact closure shall be provided for remote annunciation. Provide an elapsed time meter.

Choose one of the two following starter sections. Carefully coordinate electrical wiring requirements with electrical engineer.

## 2.7 STARTER (HIGH VOLTAGE OVER 600 VOLTS):

A. HAND-OFF-AUTO motor starter shall be Across The Line / Auto-Transformer / Primary Reactor type.

B. Isolating switch and contactor assemblies, including current limiting fuses shall be of the component-to-component design without any interconnecting cables or flexible shunts. They shall be easily removed from the front of the enclosures. Line and load cable terminations shall be completely accessible from the front.

C. The isolating switch shall be an externally operated manual three pole draw-out, such that in the open position it completely grounds and isolates the starter from the line connectors with a mechanically driven isolating shutter leaving no exposed high voltage. Integral mechanical interlocks shall prevent entry into the high voltage areas while the starter is energized and shall block accidental opening or closing of the isolating switch when the door is open or contactor is closed. The isolating switch handle shall have provision for three padlocks.

D. Current limiting power fuses shall be of the self-protecting type with visible fuse condition indicators, and with special time/current characteristics for motor service allowing proper coordination with the contractor and overload protection for maximum motor protection. The power fuses shall be vertically mounted permitting easy inspection and replacement without starter disassembly.

E. The vacuum contactor shall be slide out, with single break high pressure type main contacts with weld-resistant alloy contact faces. For vacuum contactors the contact wear shall be easily checked with the use of a feeler gauge and the bottle gap shall be adjustable. A built-in test circuit shall be included to permit checking of the starter control and pilot circuit with the high voltage de-energized and isolated, with the contactor in its normal position. In the test mode, the control circuit shall be capable of being energized through a polarized plug connector from an external 115 volt supply.

F. Low voltage control shall be isolated by a barrier from the high voltage area and provided with a separate low voltage access door. Low voltage panel shall be accessible by sliding the unit out.

G. Enclosures for the high voltage starters shall meet ANSI/NEMA ICS-6 enclosure standards and shall be NEMA 1, unless otherwise noted, completely front accessible and allowing free-standing against a wall or back-to-back mounting. Where multiple starter/structure installations are required, horizontal power bus should be used to connect between structures located on the top. Vertical bus to connect tiered starter units shall be insulated and integral to the enclosure.

H. The starter shall be able to operate in temperatures up to 120$^{o}$F.

I. All field supplied wires, bus bars and fittings shall be copper only.

J. The following starter features shall be provided:

1. Ammeter: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated.

2. Voltmeters: Three voltmeters shall be provided, each reading a phase to phase voltage.

3. Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5 percent at full load conditions.

EDIT NOTE: May be no longer required. Xcel corrects at transformer.

Coordinate carefully with chiller manufacturer and electrical engineer wiring requirements if factory or field mounted starter. Normally factory mounted started starters should be specified for machine up to 1000 tons, over 1000 tons unit mounted starters are not practical due to starter size. Consult with manufacturer.

2.8 STARTERS (LOW VOLTAGE LESS THAN 600 VOLTS:

EDIT NOTE: Stardelta

A. HAND-OFF-AUTO motor starter shall be a Star-Delta Closed Transition (Trane, McQuay, ) OR Reduced Voltage Solid State (York, , Trane, McQuay) and shall have a NEMA 1A gasketed enclosure. Enclosure shall be constructed of 12 gauge steel minimum with the exception of doors, which shall be 14 gauge steel minimum. Unit mounted enclosures shall have ventilating louvers. Gasketing shall be 2" width minimum. Each door or enclosure more than 48" high shall have 3 point vault type latches with padlockable handles. Motor starter(s) shall be factory mounted and wired on the chiller/field mounted and wired as shown on plans.

B. Motor starters shall include incoming line provisions for the number and size cables shown on the drawings. Incoming line lugs shall be copper mechanical type. Connection directly to the contactors is not permissible. All components shall be mounted to a removable steel panel of 14 gauge minimum.

C. Contactors shall be sized properly to the chiller full load and locked rotor currents. Contactors shall have double break main contacts with weld resistant silver cadmium faces. Auxiliary interlocks that interface with the control panel shall be low resistance having palladium silver contacts.

Select larger KVA capacity if desired; 2 KVA should be minimum.

D. Each motor starter shall include a 2 KVA control power transformer with fused primary and secondary. Current transformers of the proper size, ratio and burden capacity shall be provided to provide a signal to the control panel and optional devices. Control relays shall be provided within the motor starter to interface with the control panel.

E. Power wiring within the starter shall be type MTW copper stranded 90$^{o}$C. Power wire bends shall show no evidence of nicking or insulation degradation. Control wire shall be type MTW copper stranded 90$^{o}$C 14 gauge minimum.

F. The starter shall be able to operate in temperatures up to 120$^{o}$F.

G. All field supplied wires, bus bars, and fittings shall be copper only.

EDIT NOTE: Talk to Electrical, as code only requires a non-fused disconnect within sight of chiller, and a circuit breaker or fuses are provided upstream at panel.

H. The following starter features shall be provided:

1. Circuit Breaker: Starter shall contain a circuit breaker capable of breaking currents up to its interruption capacity of 65,000 amperes with ground fault protection. Operating handle and trip indicator shall be located in the door. This handle shall be capable of being padlocked.

OR

2. A non-fused disconnect switch shall be provided.

3. Ammeters: Three ammeters shall be provided, one per phase. Ammeters shall be calibrated so the inrush current can be indicated.

4. Voltmeters: Three voltmeters shall be provided, each reading a phase to phase voltage.

5. UL approved.

EDIT NOTE: Verify requirements with electrical. Usually corrected at transformer by Xcel.

6. Power Factor Correction Capacitors shall be provided to correct to 93.5-95.5 percent at full load conditions.

I. Starter shall be factory tested. Design current and overload settings shall be factory-adjusted.

## 2.9 ADJUSTABLE FREQUENCY DRIVES, FACTORY-MOUNTED ON CHILLER:

A. Adjustable frequency drives, factory mounted on chiller:

1. The centrifugal water chiller shall be furnished with a liquid cooled adjustable frequency drive as shown on the drawings. The AFD shall be factory mounted on the chiller and shipped completely factory assembled, wired and tested.

2. The AFD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The AFD control logic shall optimize chiller efficiency by coordinating compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, AFD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.

3. The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be a minimum 0.96 lagging at all speeds and loads.

4. The adjustable frequency drives shall be solid state, microprocessor based pulse width modulated (PWM) design. The AFD shall be voltage and current regulated. Output power devices shall be IGBT transistors.

5. Power semi-conductor and capacitor cooling shall be from a liquid cooled heatsink.

6. The AFDs shall each be furnished in a NEMA 1 metal enclosure having as minimum a short circuit withstand rating of 65,000 amps per UL 508. It will include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
   a. Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amp.
   b. The entire chiller package shall be UL/CUL listed.

7. The AFD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.

8. Compliance to IEE 519-1992:
   a. The AFD design shall include as standard integrated active rectification control to limit total current distortion (TDD) at the AFD to less than 5-percent.

9. Input shall be nominal 480 volts, three phase, 60 Hertz AC power, +/- 10 percent of nominal.

10. Line frequency 38-60 hertz.

11. The drive units shall include the following features:
    a. All control circuit voltages are physically and electrically isolated from power circuit voltage.
    b. One hundred fifty percent instantaneous torque available for improved surge control.
    c. Minimum and maximum speed adjustments.
    d. Soft start, adjustable linear acceleration, coast to stop.
    e. Adjustable current limiting and UL approved electronic motor overload protection.
    f. Insensitivity to incoming power phase sequence.
    g. AFD and motor protection from the following faults:
        1) Output line-to-line and line-to-ground short circuit phase loss at AFD input.
        2) Over-volt, under-volt, over temperature, phase reversal.
    h. Carrier frequency shall be fixed at 2 Khz for maximum efficiency.
    i. Automatic operation at minimum speed if the input reference is lost.

12. The following features shall be provided:
    a. A door interlocked circuit breaker capable of being padlocked.
    b. UL listed ground fault protection.
    c. Overvoltage and undervoltage protection.
    d. 3-phase sensing motor overcurrent protection.
    e. Single-phase protection.
    f. Insensitive to phase rotation.
    g. Over-temperature protection.

13. In addition to the above features the following AFD status indicators shall be available to facilitate start-up and maintenance:
    a. Output speed in hertz and rpm
    b. Input line voltage
    c. Input line kW and kilowatt-hours (KWH)
    d. Output/load amps/voltage
    e. Average current in percent RLA
    f. Load power factor
    g. Fault
    h. AFD transistor temperature
    i. Self-diagnostic service parameters

14. Service Conditions – At full output power, no external venting or heat exchangers shall be required:
    a. Operating ambient temperature 32-104 F (0-40 C).
    b. Room ambient 0-95% relative humidity.
    c. Elevation to 300 feet above 3300 feet, the rated output current shall be decreased by one percent.

15. Provide input line reactor that limits electrical power supply distribution for the variable speed drive. Input line reactor shall be unit mounted within the same NEMA-1 enclosure and shall be UL listed. Total harmonic distortion (THD) shall not exceed 3%.

16. Provide solid state manual bypass for the transfer of start and run functions from the AFD to input line power. Solid state manual bypass to provide a soft start in the bypass mode. Provide in a separate factory-mounted expansion enclosure and include inverter-off-bypass switch, separate circuit breaker with shunt trip assembly, chiller starter module, and CTs and output contactors.

17. Provide a positive electrical disconnect between the AFD and motor.

2.10 CONTROLS:

EDIT NOTE: CHOOSE

A. The chiller(s) shall be controlled by a stand-alone Direct Digital Control (DDC) System. A dedicated chiller control panel is to be supplied with each chiller by the chiller manufacturer. The panel shall be microprocessor-based, with factory wired and test for all required control components for reliable equipment operation.

OR

The chiller(s) shall be capable of communicating with Johnson Metasys System by a stand- alone Direct Digital Control (DDC) System through a BACnet interface. The following communication data shall be provided as a minimum through the BACnet interface from the chiller control panel(s):

| OBJECT TYPE | GENERIC DATA NAME |
|---|---|
| AIP | Leaving Chilled Water Temperature |
| AIP | Entering Chilled Water Temperature |
| AIP | Leaving Condenser Water Temperature |
| AIP | Entering Condenser Water Temperature |
| AIP | Percent RLA |
| AIP | Evaporator Refrigerant Pressure |
| AIP | Condenser Refrigerant Pressure |
| AIP | Compressor Discharge Refrigerant Temperature |
| AIP | Evaporator Refrigerant Temperature |
| AIP | Condenser Refrigerant Temperature |
| AIP | Oil Temperature |
| AIP | Oil Pressure Differential |
| BIP | Oil Pressure Differential |
| BIP | Condenser Water Flow |
| BIP | Chiller Water Flow |
| BIP | Manual Reset Alarm |
| BIP | Auto Reset Alarm |
| BIP | Controller Communications |

| | |
|---|---|
| BOP | Chiller Enable/Disable |
| BOP | Spare BOP |
| AOP | Chilled Water Setpoint |
| AOP | Current Limit Setpoint |

B. The chiller control panel shall provide control of chiller operation and monitoring of chiller sensors, actuators, relays and switches. The panel shall be a complete system for stand-alone chiller control and includes controls to safely and efficiently operate the chiller. Provision shall be made in the control center for inter-locking of compressor motor starter(s), chilled water flow switch(es), chilled water pump(s), condenser water pump(s) and cooling tower fan(s) per the manufacturer's recommendations.

C. Safeties: The chiller control panel shall monitor such safeties as motor starting and running, time between compressor/motor starts, low chilled water temperature, high condenser refrigerant pressure, low evaporator refrigerant temperature, evaporator and condenser water flows, low oil pressure, high oil temperature, and proper operation of unit controls and sensors.

1. To monitor bearing temperatures, all of the compressor motor bearings, (including high speed, low speed, and thrust bearings) shall have a factory installed temperature sensor installed in the oil return lines or the oil sump of each motor bearing or the oil sump. If any oil temperature reaches or exceeds a set value, the chiller control panel shall shut down the chiller operator and display the diagnostic.

2. The chiller control panel shall incorporate advanced motor protection to protect the motor throughout the starting and running cycles from the adverse effects of:
   a. Overcurrent
   b. Phase imbalance
   c. Phase reversal with indicating light
   d. Phase loss/failure with indicating light
   e. Low voltage
   f. Distribution fault protection with auto restart consisting of three-phase, current- sensing devices that monitor the status of the current.
   g. Locked rotor or incomplete start sequence.

3. Alternately the advanced motor protection system can be furnished in the starter.

4. Provide electrical interlock to prevent chiller operation when condenser water pump and chilled water pump is not operating.

5. Manual reset safety controls with separate indicating lights for:
   a. High oil temperature
   b. High and low refrigerant pressure
   c. Low oil pressure
   d. Automatic reset low leaving chilled water temperature cutout
   e. Chilled water flow and power failure

D. The chiller control panel is to be provided with a starts counter and running time meter.

E. The front of the chiller control panel shall be capable of displaying the following:

1. Entering and leaving evaporator water temperature
2. Entering and leaving condenser water temperature
3. Chilled water setpoint

4. Electrical current limit set point
5. Chiller operating mode
6. Evaporator and condenser temperatures.
7. Low and high oil pressure
8. Diagnostics: Provide a diagnostic module capable of indicating all lockout conditions specified above, plus recording the elapsed time (pre-alarm to alarm), the operating conditions of the compressor motor (amperes), refrigerant temperatures and pressures, and chilled and condenser water temperatures (entering and leaving) at time of lockout.
9. Motor current controller with load limit selector switch for full modulation from 40% to 100% full load amps.
10. Compressor HAND-OFF-AUTO switch and operating signal light.
11. Provide switches and push-buttons designed to permit indicated operations including the following:
    a. Manual and automatic operation of oil pump.
    b. Manual and automatic operation of oil separator heater.
    c. Provide indication at the micropanel of operations and cutouts including the following:
        1) Oil pump operation.
        2) Low chilled water temperature cutout.
        3) Low water flow cutout.
        4) Oil separator heater operation.
        5) Low evaporator refrigerant pressure or temperature cutout.
        6) High condenser pressure cutout.
        7) High motor winding temperature cutout (hermetic).
        8) High current cutout (open).
        9) Low oil pressure cutout.
        10) Motor overload cutout.

F. The chiller control panel shall provide evaporator freeze protection and low limit control. This control shall be used to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and temperature. A diagnostic code, reflecting the operating status, shall be automatically displayed at the front panel whenever this control is in effect.

G. The chiller control panel shall provide an alarm relay output that shall energize whenever a fault requiring manual reset is detected by the panel.

H. The chiller control panel shall provide condenser limit control to include a pressure transducer and interconnecting piping and wiring. This control shall be used to avoid high condenser refrigerant pressure tripouts during critical periods of chiller operation. The control shall take progressively more aggressive load limiting action in response to the severity of the rate of change and actual value of the condenser refrigerant pressure. A diagnostic code, reflecting the operating status, shall be automatically displayed at the front panel whenever this control mode is in effect.

I. The unit control panel shall provide leaving chilled water temperature reset based upon a 4-20ma or 0-10 VDC signal from a building automation system.

EDIT NOTE: Specify pump-out system only if desired by Owner. Verify current requirements and enforcement of Colorado Air Quality Control Division Regulation 15.

2.11 PUMP-OUT SYSTEM:

A. All units shall have either an isolatable condenser or a pump-out system complete with transfer pump, condensing unit, relief valve, and tank constructed in accordance with ASME Code for unfired pressure vessels bearing the National Board stamp. The condenser shall be sized to hold the entire refrigerant charge. The pump-out system shall hold the entire charge of the largest single chiller.

B. Pump-out systems shall be supplied and warranted by the chiller manufacturer.

2.12 REFRIGERANT MONITOR:

EDIT NOTE: COORDINATE WITH TEMP CONTROLS SECTIONS. SPECIFY MONITOR HERE, SPECIFY INTERLOCKS AND FAN CONTROL IN CONTROLS SECTION.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install chillers in accordance with manufacturer's installation instructions.

B. Install chillers plumb and level, firmly anchored, and maintain manufacturer's recommended clearances for servicing and maintenance.

C. See Section 23 05 48 for vibration isolation.

3.2 PIPING CONNECTIONS:

A. Piping installation requirements are specified in other sections of Divisions 20 through 23. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. Install piping adjacent to machine to allow servicing and maintenance.

2. Chilled Water Piping: Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, pressure gauge, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, flow meters, thermometer, pressure gauge, and union or flange.

3. Condenser Water Piping: Provide flanged connections to condenser, arranged piping to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, and pressure gauge. Connect outlet to condenser with shutoff valve, flow meter, thermometer, drain line and shutoff valve, strainer, and plugged tee.

EDIT NOTE: For heat recovery chillers.

4. Auxiliary Condenser: Provide bypass valve to bypass water flow around auxiliary condenser.

5. Vent Piping: Provide drain piping as indicated from pressure relief device to suitable drain.

3.3 FIELD QUALITY CONTROL:

A. Provide the services, to include a written report, of a factory authorized service representative to supervise the field assembly of the components, installation, and piping and electrical connections.

3.4 DEMONSTRATION:

A. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.

B. Start-up Service:

1. Evacuate, dehydrate, vacuum pump and charge with specified refrigerant, and leak test in accordance with manufacturer's instructions. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

2. Perform lubrication service, including filling of reservoirs, and confirming that lubricant is of quantity and type recommended by manufacturer.

3. Do not place chillers in sustained operation prior to initial balancing of mechanical systems for interface with chillers.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel the data contained in the Operating and Maintenance Manuals specified in PART 1 of this Section and in the LPS General Conditions of the Contract and Divisions 20 through 25.

2. Schedule training with Owner through the Architect/Engineer with at least 7 days' prior notice.

The following is a sample form which can be used and includes ratchet clause. Use on project when necessary. Requires a pre-purchase analysis by the Engineer and Owner.

CH-__: ___TON

CHILLER LIFE CYCLE COST FORM

Manufacturer_____

Model No._____

Installed Cost_____

Delivery Date_____

Peak KW:_____KW

Annual KW-H_____KW-H (Calculation based on load data provided and manufacturer's chiller performance selection)

| | KW-H | | | | | DEMAND | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| YR | KW-HR | X | $/KW-HR | = | $ | PEAK KW | X | $/KW | = | $ | Total K2-H + Demand | PW @ 9% |
| 01 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 02 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 03 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 04 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 05 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 06 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |
| 07 | _____ | X | _____ | = | ____ | _____ | X | ____ | = | ____ | $_____ | ____ |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 09 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 10 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 11 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 12 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 13 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 14 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 15 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 16 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 17 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 18 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 19 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |
| 20 | _____ | X | _____ | = | _____ | _____ | X | _____ | = | _____ | $_____ | _____ |

TOTAL PW OF OPERATING COST = $_____

CHILLER COST = $_____

TOTAL LIFE CYCLE COST = TOTAL PW OPERATING COST PLUS INSTALLED CHILLER COST $_____

The following is a sample of annual operating performance. Edit to make suitable for each project when

CH-1 (850 TON CHILLER)

| Building Tons | Annual Operating Hours | Min. Entering Condenser Water Temp. |
|---|---|---|
| 850 | 21.2 | 80 |
| 462 | 54.9 | 80 |
| 450 | 152.9 | 80 |
| 440 | 311.0 | 75 |
| 430 | 457.8 | 75 |
| 418 | 563.8 | 72 |
| 406 | 632.1 | 70 |
| 395 | 675.3 | 70 |
| 385 | 678.7 | 68 |
| 374 | 647.9 | 65 |
| 363 | 623.1 | 60 |
| 350 | 617.4 | 60 |

CH-2 (550 TON CHILLER) Alternate Bid

| Building Tons | Annual Operating Hours | Min. Entering Condenser Water Temp. |
|---|---|---|
| 550 | 21.2 | 80 |
| 462 | 54.9 | 80 |
| 450 | 152.9 | 80 |
| 440 | 311.0 | 75 |
| 430 | 457.8 | 75 |
| 418 | 563.8 | 72 |
| 406 | 632.1 | 70 |
| 395 | 675.3 | 70 |
| 385 | 678.7 | 68 |
| 374 | 647.9 | 65 |
| 363 | 623.1 | 60 |
| 350 | 617.4 | 60 |

**END OF SECTION 23 64 16.16**

Edit for scroll or reciprocating compressors.

# SECTION 23 64 19 - RECIPROCATING / SCROLL CHILLERS

PART 1 - GENERAL

1.1 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants & environmentally friendly.

B. No CFC-based refrigerants shall be used.

1.2 DESCRIPTION OF WORK:

A. Extent of reciprocating/scroll liquid chiller work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of reciprocating/scroll liquid chillers specified in this section include the following:

1. Water-cooled.

2. Condenser-less.

3. Packaged outdoor air-cooled.

4. Heat recovery.

C. Refer to other Division 3 and Divisions 20 through 25 sections for concrete pads, piping, piping specialties, pumps, and valves, which are required external to reciprocating chillers for installation.

D. Refer to other Division 23 sections for field-installed automatic temperature controls required in conjunction with reciprocating chillers.

E. Refer to Section 23 05 48 "Vibration Control" for vibration control work required in connection with reciprocating chillers.

F. Manufacturers shall be responsible to provide any information to the contractor prior to bidding which may impact the installed cost for the contractor including but not limited to:

1. Power wiring sizing quantity and type of conductors.
2. Control Power.
3. Auxiliary piping connections.

1.3 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of reciprocating chillers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 5 years of successful installation experience with projects utilizing reciprocating chillers similar to those required for this project.

C. ARI Compliance: Test and rate reciprocating chillers in accordance with ARI Std 590, "Standard for Reciprocating Water-Chilling Packages."

D. ASHRAE Compliance: Construct and install reciprocating chillers in accordance with ASHRAE Std 15, "Safety Code for Mechanical Refrigeration". Provide Energy Efficiency Ratio (EER) for reciprocating chillers not less than prescribed by ASHRAE Std 90A, "Energy Conservation in New Building Design".

E. NEC Compliance: Comply with applicable NEC requirements pertaining to electrical power and control wiring for construction and installation of reciprocating chillers.

F. ANSI/ASHRAE Compliance: Comply with ANSI 15 safety code requirements pertaining to unit construction of reciprocating chillers.

G. ASME Compliance: Construct and test reciprocating air- cooled liquid chiller in accordance with ASME Boiler and Pressure Vessel Code, Section 8.

1. Stamp cooler with ASME mark when cooler has been successfully tested in accordance with ASME Code. Pressure test cooler for refrigerant working side pressure of not less than 235 PSIG (1620 kPa), and water side pressure of not less than 150 PSIG (1034 kPa). Leak test cooled condenser coils at 150 PSIG (1034 kPa) and pressure test coils at 450 PSIG (3103 kPa).

H. NEMA Compliance: Provide high-efficiency motors for reciprocating chillers which comply with NEMA Stds Pub/No.'s MG 1, 2, 3, 10, and 11.

I. UL Compliance: Comply with applicable requirements of UL 465, "Central Cooling Air Conditioners", pertaining to construction and installation of reciprocating chillers. Provide reciprocating chillers which are UL-listed and labeled.

J. ANSI/UL 984: Safety standards for hermetic motor compressors.

## 1.4 SUBMITTALS:

A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. Provide description of alternative refrigerant including:

1. Potential lifetime in years.
2. Ozone depletion factor potential.
3. Global warming potential.

The equipment provided shall provide the scheduled capacity with the substitute refrigerant proposed, the nominal equipment capacity reduction effects (if any), performance in KW/TON, the refrigerant change out procedure and long term maintenance effects the new refrigerant has on the equipment.

B. Product Data: Submit manufacturer's technical product data, including rated capacities for chillers indicated, sound power levels, weights (shipping, installed, and operating), furnished specialties and accessories; and rigging, installation, and start-up instructions.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, methods of assembly of components, and location and size of each field-connection.

D. Provide templates for anchor bolt placement in concrete pad. Deliver templates to concrete installer so work by others is not delayed.

E. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

F. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

G. Maintenance Data: Submit maintenance data and parts list for each reciprocating chiller, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handle reciprocating chillers and components properly to prevent damage, breaking, denting and scoring. Do not install damaged reciprocating chillers or components; replace with new. Comply with manufacturer's rigging and installation instructions for unloading reciprocating chillers, and transporting them to final location.

B. Store reciprocating chiller and components in clean dry space. Protect from weather, dirt, fumes, water, construction debris, and physical damage. Storage temperatures for unit controls are not to exceed 185 deg. F (85 deg. C).

1.6 WARRANTY:

A. Provide (5) five year motor/compressor replacement warranty in addition to the 1-year warranty required under Section 23 05 00. Warranty shall include parts and labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

Select scroll or reciprocating.

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

1. Water-Cooled Scroll/Reciprocating Chillers:
   a. Carrier
   b. McQuay Group; McQuay-Perfex Inc.
   c. Trane Company.
   d. Bohn Heat Transfer Div; Gulf + Western Mfg Co.
   e. York Div; Borg-Warner Corporation.

2. Condenserless Reciprocating Chillers:
   a. Carrier
   b. McQuay Group; McQuay-Perfex Inc.
   c. Trane Company.
   d. York Div; Borg-Warner Corporation.

3. Outdoor Air-Cooled Scroll/Reciprocating Liquid Chillers:
   a. Carrier
   b. McQuay Group; McQuay-Perfex Inc.
   c. Trane Company.
   d. Bohn Heat Transfer Div; Gulf + Western Mfg Co.
   e. York Div; Borg-Warner Corporation.

4. Heat Recovery Reciprocating Chillers:
   a. Carrier
   b. McQuay Group, McQuay-Perfex Inc.
   c. Trane Co.

2.2 WATER-COOLED SCROLL / RECIPROCATING LIQUID CHILLERS:

Select either reciprocating or scroll type compressors, use higher working pressure(s) ratings for scroll and 3600 rpm for scroll, 1750 rpm for reciprocating compressors.

A. General: Provide factory-assembled and tested scroll/reciprocating water-cooled liquid chillers as indicated, consisting of compressors, condenser, evaporator, thermal expansion valve, and control panel. Provide capacity and electrical characteristics as scheduled.

B. Refrigerant: Provide full operating charge of refrigerant and oil.

Select pressures.

C. Evaporator: Provide shell-and-tube design with seamless copper tubes roller expanded into tube sheets. Design, test, and stamp for refrigerant side working pressure of 300/225 PSIG minimum, and water side working pressure of 150/300 PSIG minimum, in accordance with ASME Pressure Vessel Code. Insulate with 3/4" thick minimum flexible unicellular insulation with maximum K-value of 0.28. Provide water drain connections and bulb wells for temperature controller, low-temperature cutout, and inlet/outlet temperature sensors.

1. Multiple-Compressor Units: Provide independent multiple refrigerant circuits with gasketed evaporator heads.

Select pressures.

D. Condenser: Provide shell-and-tube design with seamless integral-fin copper tubes expanded into tube sheets, with tubes mechanically cleanable and replaceable through removable headers. Design, test, and stamp for refrigerant side working pressure of 450/300 PSIG minimum, and water side working pressure of 300/150 PSIG minimum, in accordance with ASME Pressure Vessel Code. Provide safety relief valve with pressure rating not to exceed condenser shell side working pressure. Provide integral subcooler circuit.

1. Multiple-Compressor Units: Provide independent multiple refrigerant circuits.

E. Compressor: Provide direct-drive, 1750/3600 RPM, accessible hermetic, multi-cylinder reciprocating/scroll compressor with multistep capacity control. Provide crankcase heater and suction strainer. Mount compressor on vibration isolators within chiller housing.

1. Lubrication: Provide reversible, positive-displacement oil pump. Provide oil charging valve, oil level sight glass, oil filter, and magnetic plug or strainer, arranged to ensure adequate lubrication during starting, stopping, and normal operation.

2. Motor: Provide suction gas-cooled motor with high temperature thermostat protection.

3. Oil Sump Heater: To evaporate refrigerant returning to crankcase during shut down, energize when compressor is not operating.

F. Capacity Modulation: Provide step capacity control by means of cylinder unloaders and compressor staging, from return water temperature.

G. Refrigerant Circuit: Provide the following for each refrigerant circuit:

1. Liquid line solenoid valve.

2. Filter dryer.

3. Liquid line sight glass and moisture indicator.

4. Thermal expansion valve.

5. Suction and discharge line service valves.

6. Compressor discharge service valve.

7. 1/4" flare charging port.

8. Insulated suction line.

H. Control Panel:

1. Locate on the chiller, factory wired a [NEMA 1] unit control panel, containing both a starter section and a controls section with point power correction.

2. Provide the following devices in starter section:
   a. Access for power wiring.
   b. Factory wired single point power hook-up to terminal block. / non-fused disconnect switch.
   c. Three-phase solid-state overload protection.
   d. Customer wired grounding lug.
   e. Control power transformer with primary and secondary fused protection.
   f. Factory wired across-the-line starter on compressor motors 20 hp or smaller.
   g. Factory wired part winding starter, with solid state fixed off/on timers on all compressor motors over 20 hp.
   h. Non-recycling compressor overloads.
   i. Phase loss/reversal/imbalance and under-voltage/over-voltage minder on main power connection. A 15% under-voltage condition for 4-5 seconds will shut unit off and require manual reset.

3. Provide the following devices on control panel face:
   a. System start/stop switch.
   b. Compressor running indication lights or digital display.
   c. High and low pressure cutout lights or digital display.
   d. Motor overload lights or digital display.

4. Provide the following safety controls diagnostic display so there is automatic shutdown of the machine and requires manual reset:
   a. Low chilled water temperature.
   b. High condenser refrigerant discharge pressure.
   c. Low suction pressure.
   d. Chilled water flow detection.
   e. Motor current overload and phase loss.
   f. High motor winding temperature.
   g. Relay or contact for emergency shutdown.

h. Low oil pressure cut-off.

5. Provide the following safety controls diagnostic display so there is automatic shutdown of the machine with automatic reset:
   a. Over voltage.
   b. Under voltage.
   c. Phase reversal.
   d. Chill water flow interlock.

6. Provide the following operating controls:
   a. Machine automatically sheds compressors to prevent automatic shut-down in the event of low evaporator refrigerant temperature, high condenser refrigerant pressure, motor current overload, and high refrigerant discharge temperature.
   b. Time of day scheduling that turns chiller on and off using a contact closure from field supplied clock.
   c. Pump-out mode at unit shut-down.
   d. If unit is dual circuited, provide automatic circuit to circuit lead-lag capability and provide a defeat switch to disable changeover of the lead-lag function.
   e. KW demand limiting that disables second compressor on each refrigeration circuit using a contact closure.
   f. Solid state lockout timer to prevent compressor short-cycling.
   g. Suction and discharge refrigerant pressure gauges.
   h. Cycle counter and operating hour meter.
   i. Microprocessor-based leaving chilled water temperature PID (proportional, integral, derivative) controller.

| Edit for the following accessories. |
|---|

I. Accessories: Provide the following accessories:

1. Hot gas bypass valve, factory-piped and wired.

2. Load limit thermostat, if required.

3. Acoustically lined enclosure.

4. Vapor-proof chilled water flow switch.

5. Suction, discharge, and oil pressure gages.

6. Compressor suction and discharge service valves.

| Select type of vibration isolator or specify in Section 23 05 48. |
|---|

7. Vibration isolators of the following type:
   a. Spring isolators with vertical restraint springs.
   b. Equipment rails and vertically-restrained spring isolators.
   c. Fabricated equipment base and spring isolators.

8. Anti-recycle timer if protection against liquid slugging is not provided.

9. Manual pump-down switch.

10. Condenser water temperature sensors.

11. Building automation system interface.

2.3 CONDENSERLESS RECIPROCATING CHILLERS:

A. General: Provide factory-assembled and tested condenser-less reciprocating liquid chillers as indicated, consisting of compressors, evaporator, thermal expansion valve, and control panel. Provide capacity and electrical characteristics as scheduled.

B. Refrigerant: Provide holding charge of refrigerant and compressor operating charge of oil.

C. Evaporator: Provide shell-and-tube design with seamless copper tubes roller expanded into tube sheets. Provide removable heads on both ends. Design, test, and stamp for refrigerant side working pressure of 225 PSIG minimum, and water side working pressure of 150 PSIG minimum, in accordance with ASME Pressure Vessel Code. Insulate with 1/2" minimum flexible unicellular insulation with maximum K- value of 0.28. Provide water drain connection and bulb wells for temperature controller and low temperature cutout.

1. Multiple-Compressor Units: Provide independent multiple refrigerant circuits.

D. Compressors: Provide direct drive, 1750 RPM, accessible hermetic, multi-cylinder reciprocating compressors with multistep capacity control. Provide crankcase heater and suction strainer. Start compressor unloaded for single compressor units. Mount compressors on vibration isolators within chiller housing.

1. Lubrication: Provide reversible, positive-displacement oil pump. Provide oil filter and magnetic plug or strainer, arranged to ensure adequate lubrication during starting, stopping, and normal operation.

2. Motor: Provide suction gas-cooled motor with high temperature thermostat protection.

E. Capacity Modulation: Provide step capacity control by means of cylinder unloaders and/or compressor staging, from return water temperature.

F. Refrigerant Circuit: Provide the following for each refrigerant circuit:

1. Liquid line solenoid valve.
2. Filter dryer.
3. Liquid line sight glass and moisture indicator.
4. Thermal expansion valve.
5. Compressor discharge and suction service valves.
6. 1/4" flare charging port.
7. Insulated suction line.

Design Note: Provide electrical engineer chiller manufacturer's starter wiring information.

G. Control Panel:

1. Locate on the chiller, factory wired a NEMA 1 unit control panel, containing both a starter section and a controls section with point power correction.

2. Provide the following devices in starter section:
   a. Top access for power wiring.

b. Factory wired single point power hook-up to terminal block / non-fused disconnect switch.
c. Three-phase solid-state overload protection.
d. Customer wired grounding lug.
e. Control power transformer with primary and secondary fused protection.
f. Factory wired across-the-line starter on compressor motors 20 hp or smaller.
g. Factory wired part winding starter, with solid state fixed off/on timers on all compressor motors over 20 hp.
h. Non-recycling compressor overloads.
i. Phase loss/reversal/imbalance and under-voltage/ over-voltage minter on main power connection. A 15% under-voltage condition for 4-5 seconds will shut unit off and require manual reset.

3. Provide the following devices on control panel face:
   a. System start/stop switch.
   b. Compressor running indication lights or digital display.
   c. High and low pressure cutout lights or digital display.
   d. Motor overload lights or digital display.

4. Provide the following safety controls diagnostic display so there is automatic shutdown of the machine and requires manual reset:
   a. Low chilled water temperature.
   b. High condenser refrigerant discharge pressure.
   c. Low suction pressure.
   d. Chilled water flow detection.
   e. Motor current overload and phase loss.
   f. High motor winding temperature.
   g. Relay or contact for emergency shutdown.
   h. Low oil pressure cut-off.

5. Provide the following safety controls diagnostic display so there is automatic shutdown of the machine with automatic reset:
   a. Over voltage.
   b. Under voltage.
   c. Phase reversal.
   d. Chill water flow interlock.

6. Provide the following operating controls:
   a. Machine automatically sheds compressors to prevent automatic shut-down in the event of low evaporator refrigerant temperature, high condenser refrigerant pressure, motor current overload, and high refrigerant discharge temperature.
   b. Time of day scheduling that turns chiller on and off using a contact closure from field supplied clock.
   c. Pump-out mode at unit shut-down.
   d. If unit is dual circuited, provide automatic circuit to circuit lead-lag capability and provide a defeat switch to disable changeover of the lead-lag function.
   e. KW demand limiting that disables second compressor on each refrigeration circuit using a contact closure.
   f. Solid state lockout timer to prevent compressor short-cycling.
   g. Suction and discharge refrigerant pressure gauges.
   h. Cycle counter and operating hour meter.
   i. Microprocessor-based leaving chilled water temperature PID (proportional, integral, derivative) controller.

H. Accessories: Provide the following accessories:

1. Hot-gas bypass valve, factory-piped and -wired.

2. Load limit thermostat, if required.

3. Acoustically lined enclosure.

4. Vapor-proof chilled water flow switch.

5. Suction, discharge, and oil pressure gages.

Select type of vibration isolator.

6. Vibration isolators of the following type:
   a. Spring isolators.
   b. Equipment rails and vertically-restrained spring isolators.
   c. Fabricated equipment base and spring isolators.

7. Anti-recycle timer.

8. Timed periodic pump-out.

9. Hot gas muffler.

10. Alarm package, field-installed, including audible alarm and pilot lights indicating loss of evaporator flow, low temperature, compressor malfunction, power ON and compressor ON.

2.4 OUTDOOR AIR-COOLED LIQUID CHILLERS:

A. General: Provide factory-assembled and tested outdoor air- cooled reciprocating liquid chillers as indicated, consisting of compressors, evaporator, condensers, thermal expansion valves, and control panels. Provide capacity and electrical characteristics as scheduled.

B. Refrigerant: Provide full operating charge of refrigerant and oil.

C. Housing: Housing shall be minimum 14-gauge welded galvanized steel frame with 14- and 16- gauge galvanized steel panels and access doors with corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts and components.

Select pressure rating 150 lb recip/300 lb scroll compressor.

D. Evaporator: Provide shell-and-tube design with seamless copper tubes roller expanded into tube sheets. Design, test, and stamp for refrigerant side working pressure of 225 PSIG minimum, and water side working pressure of 150/300 PSIG minimum, in accordance with ASME Pressure Vessel Code. Provide one water pass with series of internal baffles. Insulate with 3/4" minimum flexible unicellular insulation with maximum K-value of 0.26. Provide water drain connection and bulb wells for temperature controller and low-temperature cutout.

1. Heater Tapes: Provide electrical resistance heater tape on evaporator to protect against freezing at -20 deg.F (- 29 deg.C) ambient at no-flow condition.

2. Multiple-Compressor Units: Provide independent multiple refrigerant circuits with gasketed evaporator heads.

E. Condenser: Construct coils with configurated aluminum fins mechanically bonded to seamless copper tubing. Provide integral subcooling circuit with liquid accumulators. Leak test coils with air under water at 425 PSIG air pressure. Provide protective grilles over exposed coil faces.

1. Multiple-Compressor Units: Provide multiple circuited condenser coils.

2. Condenser Fans: Provide propeller fans, direct or belt [ ] driven, draw-through design, statically and dynamically balanced. Provide permanently lubricated ball-bearing motors with overload protection. Provide protective grille over air discharge.

Select temperature for low ambient control.

3. Low Ambient Control: Provide head pressure control, designed to operate at temperatures down to [0] deg.F (-18 deg.C).

Specify minimum no. of steps.

F. Compressors: Provide direct drive 1750/3600 RPM, multi-cylinder scroll/reciprocating compressors with crankcase heater; either semi-hermetic or hermetic, with a minimum [ ] steps of capacity control, provided by cylinder unloading or compressor staging, or combination of both. Mount compressors on vibration isolators within chiller housing.

1. Lubrication: Provide oil pump, oil filter, oil level sight glass, and oil charging valve.

G. Capacity Modulation: Provide step-control by means of cylinder unloading and/or compressor staging, from return water temperature.

H. Refrigerant Circuit: Provide for each refrigerant circuit the following:

Use multiple circuits on larger sizes.

Provide multiple independent separate refrigerant circuits with a minimum of two.

1. Liquid line solenoid valve.
2. Filter dryer.
3. Liquid line sight glass and moisture indicator.
4. Thermal expansion valve.
5. Insulated suction line.
6. Suction and discharge valves.

Design Note: Provide electrical engineer chiller manufacturer's starting wiring information.

I. Controls and Control Panels:

1. Locate on/near chiller, factory wired/NEMA 1 unit control panel, containing both a controls section as well as a starter section.

2. Provide the following devices in starter section:
   a. Top access for power wiring.
   b. Factory wired single point power hook-up to terminal block /unit mounted, non-fused disconnect switch.
   c. Three-phase solid-state overload protection.
   d. Customer wired grounding lug.
   e. Control power transformer with primary and secondary fused protection.

f. Factory wired part winding/across-the-line starter with solid state fixed off/on timers on all compressor motors.
g. Non-recycling compressor overloads.
h. Phase loss/reversal/imbalance and under-voltage monitor on main power connection. A 15% under voltage condition for 4-5 seconds will shut unit off and require manual reset.

3. Provide the following devices in the control panel:
   a. Compressor run lights.
   b. System start-stop switch.
   c. Low pressure lockout lights.
   d. Terminal strips.
   e. Central micro-processor
      1) Leaving fluid setpoint.
      2) Delta T setpoint.
      3) # of stages.
   f. Control power fuses.
   g. Motor protection/oil failure controller.
   h. Indicating lights for load limit.
   i. Stages of unit unloading.

4. Provide the following safety controls arranged so that operating any one will shut down machine and require manual reset:
   a. Low chilled water temperature switch.
   b. High discharge pressure switch for each compressor.
   c. Low suction pressure switch for each compressor.
   d. Oil pressure switch.
   e. Current overload.
   f. Motor temperature.

5. Provide the following safety controls so there is automatic shutdown of the machine with automatic reset:
   a. Over voltage.
   b. Under voltage.
   c. Phase reversal.
   d. Chilled water flow interlock.
   e. Condenser water flow interlock.

6. Provide the following operating controls:
   a. Multi-step chilled water temperature controller, which cycles compressor and activates cylinder unloaders.
   b. Five minute off timer prevents compressor from short cycling.
   c. Part winding/Across-the-line solid state start timer.
   d. Provide automatic circuit to circuit lead-lag capability to allow for equal run time per compressor.
   e. Periodic pump-out timer to pump down on chilled water flow and high evaporator refrigerant pressure.
   f. Load limit thermostat to limit compressor loading on high return water temperature.
   g. Power supply monitor to protect unit by stopping compressor on phase loss, phase reversal, incorrect phase sequence, and low voltage.
   h. Cycle counter and operating hour meter.

7. Provide pre-piped gauge board with pressure gauges for suction and discharge refrigerant pressures, and oil pressures for each compressor.

Carefully select the following options.

8. Provide alarm package with test button and indicating lights which indicate control circuit is energized and compressor is running, and will sound an audible alarm and light an indicating light upon detection of compressor malfunction, low chilled water temperature, or evaporator water flow failure.

9. Provide remote mounted microprocessor-based panel that allows multiple units to operate in series or parallel.

10. Provide chilled water reset algorithm in the microprocessor that resets leaving water temperature based on [ambient] or [zone] temperature. Provide field installed sensor.

11. Provide a field installed ice panel add-on control that enables the chiller to make ice during off-peak hours and make standard temperature chilled water during high-energy demand hours.

J. Accessories: Provide the following accessories:

1. Hot gas bypass valve, factory-piped and wired.

2. Load limit thermostat, if required.

3. Vapor-proof chilled water flow switch.

4. Suction and discharge gages.

5. Oil pressure gages except for hermetic compressors.

Select type of vibration isolator or specify in Section 23 05 48.

6. Vibration isolators of the following type:
   a. Spring isolators.
   b. Equipment rails and vertically-restrained spring isolators.
   c. Fabricated equipment base and spring isolators.

7. Low ambient dampers for $0^{o}$F ambient start-up and run.

8. Copper condenser fins.

2.5 HEAT RECOVERY RECIPROCATING CHILLERS:

A. General: Provide factory-assembled and tested reciprocating water-cooled liquid chillers as indicated, consisting of compressors, condenser, evaporator, receiver, thermal expansion valve, control valves, and control panel. Provide capacity and electrical characteristics as scheduled.

B. Refrigerant: Provide full operating charge of refrigerant and oil.

C. Evaporator: Provide shell-and-tube design with seamless copper tubes roller expanded into tube sheets. Design, test, and stamp for refrigerant side working pressure of 225 PSIG minimum, and water side working pressure of 150 PSIG minimum, in accordance with ASME Pressure Vessel Code. Insulate with 1/2" minimum flexible unicellular insulation with maximum K-value of 0.28. Provide water drain connection.

D. Condenser: Provide shell-and-tube design with seamless integral-fin copper-nickel tubes expanded into tube sheets. Design, test and stamp for refrigerant side working pressure of 450 PSIG, and water side working pressure of 150 PSIG, in accordance with ASME Pressure Vessel Code. Provide 450 PSIG safety relief valve on condenser. Provide subcooler circuit in condenser. Factory-mount condenser on reciprocating chiller, connected by single compressor discharge line to remote air-cooled condenser for parallel refrigerant flow.

E. Compressors: Provide direct drive 1,750 RPM, multicylinder reciprocating compressors with crankcase heater; either semi-hermetic or hermetic, but with minimum steps of capacity control as scheduled, provided by cylinder unloading or compressor staging, or combination of both. Mount compressors on vibration isolators within chiller housing.

F. Capacity Modulation: Provide step capacity control by means of cylinder unloaders and/or compressor staging, from return water temperature.

G. Refrigerant Circuit: Provide for refrigerant circuit, factory-mounted, the following:

1. Liquid line solenoid valve.
2. Filter dryer.
3. Liquid line sight glass.
4. Thermal expansion valve.
5. Compressor discharge service valve.
6. 1/4" flare charging port.
7. Insulated suction line.
8. Hot gas muffler.
9. Refrigerant shutoff valves around refrigerant controls and components.

H. Receiver: Provide factory-mounted liquid line receiver; designed, tested, and stamped for working pressure of 450 PSIG, in accordance with ASME Pressure Vessel Code. Provide 450 PSIG safety relief valve and 2 sight glasses.

I. Control Panel: Provide control panel for compressor, factory-wired for external connection only. Provide 2 sections in panel, electrical and refrigeration.

1. Refrigeration Section: Provide the following:
   a. High-pressure cutout.
   b. Low-pressure cutout.
   c. Motor protection.
   d. Oil-pressure cutout.
   e. Low chilled water temperature cutout.
   f. Chilled water temperature controller.

2. Electrical Section: Provide the following:
   a. Power controls for part-wind or full voltage start.
   b. Control power transformer for 115V control voltage.
   c. Terminal strip.
   d. Pump-down control relay.
   e. Compressor starter relay.
   f. Reset relay.
   g. Non-recycling compressor overload relay.
   h. Time delay relay.
   i. Interlocks for remote air-cooled condenser con

J. Accessories: Provide the following accessories:

1. Hot gas bypass valve, factory-piped and wired.

2. Load limit thermostat, if required.

3. Acoustically lined enclosure.

4. Chilled water flow switch.

5. Suction, discharge, and oil pressure gages.

6. Vibration isolators of the following type:
   a. Spring isolators.
   b. Equipment rails and vertically-restrained spring isolators.
   c. Fabricated equipment base and isolators.

7. Anti-recycle timer and timed periodic pump-out.

K. Auxiliary condenser, factory-mounted, connected by single compressor discharge line for parallel refrigerant flow.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Installer must examine areas and conditions under which reciprocating chillers are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.2 INSTALLATION OF RECIPROCATING CHILLERS:

A. General: Install reciprocating chillers in accordance with manufacturer's written instructions. Install units plumb and level, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

B. Support: Install floor-mounted units on reinforced concrete pad. Furnish anchor bolts, which are to be inserted in concrete pad to Concrete Installer.

C. Support: Install roof-mounted units on structural steel mechanical equipment stand. Anchor unit to stand with removable type fasteners.

1. Construct mechanical equipment stand as indicated, and in accordance with NRCA Handbook of Accepted Roofing Knowledge, Detail "N".

2. Mechanical equipment stand is specified in Division 5; not work of this section.

D. Chilled Water Piping: Refer to Section 23 21 16 "Piping Specialties". Connect inlet to evaporator with controller bulb well, shutoff valve, thermometer, strainer, flow switch, flexible pipe connector, drain valve, pressure gage, and union or flange. Connect outlet to evaporator with shutoff valve, balancing cock, flow meter, thermometer, flexible pipe connection, pressure gage, drain valve, and union or flange.

E. Condenser Water Piping: Refer to Section 23 21 16 " Piping Specialties". Provide flanged or union connections to condenser, arranged to allow removal of condenser heads. Connect inlet to condenser with shutoff valve, thermometer, plugged tee, pressure gage, flexible pipe connector, and union or flange. Connect outlet to condenser with shutoff valve, flow meter, thermometer, drain valves and shutoff valve, strainer, plugged tee, flexible pipe connector, and union or flange.

F. Refrigerant Piping: Refer to Section 23 21 16 " Piping Specialties". Provide piping between chiller and condenser as indicated, and in accordance with installation instructions of both chiller and condenser manufacturers.

G. Relief Piping: Provide relief piping as indicated from refrigerant pressure relief rupture disc on chiller to outside building atmosphere; size piping as recommended by chiller manufacturer, and terminate with gooseneck facing down.

H. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Contractor.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to manufacturer and equipment installer.

I. Control: Furnish field-installed automatic temperature control requirements to Controls Installer.

J. Start-up: Chiller start-up shall be by factory authorized service representative in accordance with manufacturer's recommendations. Test controls and demonstrate compliance with requirements. Replace damaged, or malfunctioning, controls and equipment and retest.

1. Do not place chillers in sustained operation prior to initial balancing of mechanical systems, which interface with the reciprocating chillers.

3.3 TRAINING OF OWNER'S PERSONNEL:

A. Provide services of manufacturer's technical representative for two 8-hour days to instruct Owner's personnel in operation and maintenance of reciprocating chillers.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

**END OF SECTION 23 64 19**

# SECTION 23 65 00 - COOLING TOWERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of factory-fabricated cooling tower work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Types of factory-fabricated cooling towers specified in this section include the following:

1. Factory-Fabricated Cooling Towers:
    a. Induced-draft, propeller fan, crossflow.
    b. Forced-draft, propeller fan, crossflow.
    c. Forced-draft, propeller fan, counterflow.
    d. Forced-draft, centrifugal fan, counterflow.
2. Ejector Cooling Towers
3. Condenser Water Holding Tanks

C. Refer to other Division 20 through 25 sections for condenser water piping, condenser water treatment, vibration control, remote cooling tower sump, temperature controls; not work of this section.

D. Refer to Division 26 sections for the following work; not work of this section.

1. Power supply wiring from power source to power connection on cooling tower. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.
2. Interlock wiring between cooling towers and between cooling towers and field-installed control devices.
    a. Interlock wiring specified as factory-installed is work of this section.

E. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and cooling tower control panels.
    a. Control wiring specified as work of Section 23 09 23 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of factory-fabricated cooling towers, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Provide manufacturer's certification of tower cooling capacity, based on factory-performance tests, and provide performance curve plotting Leaving Water Temperature (LWT) against Wet-Bulb Temperature (WBT).

C. Certify tower wind resistance to withstand pressure indicated, in any direction.

D. Certify earthquake resistance against loading as indicated.

E. Codes and Standards:

1. UL and NEMA Compliance: Provide electric motors and electrical components required as part of factory-fabricated cooling towers, which have been listed and labeled by UL and comply with NEMA Standards.

2. NEC Compliance: Install cooling towers in accordance with NFPA 70 "National Electrical Code".

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities, pressure drop, fan performance data, weights (shipping, installed, and operating), installation and start-up instructions, and rating curves with selected points clearly indicated.

B. Shop Drawings: Submit assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of all components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to cooling towers. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance data and parts list for each cooling tower, control, and accessory; including "troubleshooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams, in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

F. Certifications: Submit required certifications and written tests results for required testing.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle cooling towers and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged cooling towers or components; replace with new.

B. Store cooling towers and components in clean place. Protect from dirt, fumes, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading cooling towers, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Factory-Fabricated Cooling Towers:

a. Baltimore Aircoil Co., Inc.

b. Ceramic Cooling Tower Co.

c. Marley Cooling Tower Co.

d. Halstead & Mitchell Co.; Div. of Halstead Industries.

e. Recold.

f. Zurn Industries, Inc.; Cooling Tower Div.

2. Ejector Cooling Towers:

a. Baltimore Aircoil Co., Inc.

3. Condenser Water Storage Tank:

a. American Steel and Iron Co.

2.2 FACTORY-FABRICATED COOLING TOWERS:

Design Note: Verify if local code authority requires cooling tower to have fire protection system inside cooling tower, for either plastic cell media or plastic tower casing.

A. General: Fabricate cooling towers using manufacturer's standard design, materials, and construction in accordance with published product information, except as otherwise indicated.

B. Design structural system for the following live loading in addition to tower dead loads and operating loads:

1. Wind Loading: 30 psf on exposed vertical surfaces.

2. Earthquake Resistance: Acceleration of 1.0 G horizontally through center of gravity.

C. Fabricate structural system including assembly of collecting basin and steel casings by one of the following methods:

1. Bolt connections with fasteners having equal or better corrosion-resistance than materials fastened; seal joints to make watertight enclosure.

2. Weld connections and weld metal seams continuously to make watertight.

3. Provide rigging supports on structure for final rigging.

D. Casings: One of the following materials fabricated and installed by manufacturer to make tower watertight.

1. Provide galvanized steel.

2. Provide hot-dipped galvanized steel with polymer coating.

3. Provide stainless steel.

E. Collecting Basin and Sump: One of the following materials and types of units, designed and installed to support water and to ensure water tightness:

1. Provide galvanized steel.

2. Provide hot-dipped galvanized steel with polymer coating.

3. Provide stainless steel.

4. Provide integral type collecting basin and sump with lift-out strainer with openings smaller than nozzle orifices, and with connections for drain, overflow and water make-up.

5. Provide integral type collecting basin and sump with oversized bottom outlet drain, for use with remote sump.

F. Wetted-Surface Fill: One of the following materials fabricated into wave-formed configurations installed by manufacturer to assure break-up of water into droplets.

1. Provide galvanized steel sheets.
2. Provide hot-dipped galvanized steel sheets with polymer coating.
3. Provide stainless steel sheets.
4. Provide vertical sheets of polyvinyl chloride plastic having flame spread rating of 5 per ASTM E84.

G. Drift Eliminators: One of the following materials fabricated by manufacturer into three-pass configuration to limit drift-loss to indicated maximum percentage of circulating-water flow-rate:

1. Provide polyvinyl chloride plastic, having flame spread rating of 5 per ASTM E84.
2. Provide galvanized steel.
3. Provide hot-dipped galvanized steel with polymer coating.
4. Provide stainless steel.

H. Louvers: One of the following materials designed and installed by manufacturer, and of sufficient thickness and rigidity to prevent visible sagging:

1. Provide galvanized steel.
2. Provide hot-dipped galvanized steel with polymer coating.
3. Provide stainless steel.
4. Provide fiberglass reinforced plastic (FRP).

I. Water Distribution System: Galvanized steel, open basin, gravity-flow type with plastic metering orifices; installed by manufacturer to ensure even distribution of water over wetted-surface fill.

J. Water Distribution System: One of the following materials designed and installed by manufacturer to ensure even distribution of water over wetted-surface fill.

1. Galvanized steel pipe header and removable galvanized steel pipe branches.
2. Schedule 40 PVC pipe header and removable schedule 40 PVC pipe branches.
3. Nozzles: Provide removable plastic, brass, or ceramic nozzles.
4. Pressure Drop: Maximum pressure drop of 5 psi.

K. Basin Covers: One of the following materials, removable and with handles, installed by manufacturer to prevent debris from entering basin and to inhibit algae growth by eliminating sunlight:

1. Provide galvanized steel sheet.
2. Provide hot-dipped galvanized steel with polymer coating.

L. Discharge Dampers: Provide airfoil capacity control dampers and linkage for cells as indicated, formed of galvanized steel sheets, designed and installed by manufacturer to control air flow and to provide linear control of tower capacity.

M. Inlet Screens: One of the following materials, mounted in removable frames by manufacturer:

1. Provide galvanized steel mesh.

2. Provide hot-dipped galvanized steel mesh with polymer coating.
3. Provide stainless steel mesh.

N. Discharge Hoods: One of the following materials, including access doors, fabricated and installed by manufacturer to prevent recirculation of discharge air:

1. Provide galvanized steel.
2. Provide hot-dipped galvanized steel with polymer coating.
3. Provide stainless steel.

O. Sound Attenuators: One of the following materials, factory-fabricated and -mounted by manufacturer at intake and discharge of tower, lined with water-proof sound-absorbent non-combustible material held in place by manufacturer's standard method except as otherwise indicated:

1. Line attenuators with glass fiber.
    a. Secure lining with galvanized steel retainers.
    b. Secure lining with stainless steel retainers.

P. Basin Heaters: Provide galvanized steel coils designed to be supplied with one of the following:

1. Hot-water at temperature of 180 deg F (82 deg C).
2. Steam at minimum pressure of 5 psi.

Q. Basin Heaters: Provide electric immersion heaters including thermostat and low-water cutout, in weatherproof enclosure, for field wiring.

R. Provide basin heaters sized by manufacturer to maintain basin water at 40 de. F (4.4 deg C) at ambient temperature of 0 deg. F (-18 deg C) and wind velocity of 15 mph.

S. Handrails: Provide galvanized steel pipe rails of required height above tower. Include knee and toe rails of required diameter and heights.

T. Ladders: Provide galvanized steel or aluminum ladder, to top of cooling tower working surface.

1. Safety Cage: Include safety cage of galvanized steel or aluminum.

U. Water Level Control: Provide plastic or bronze mechanical float with adjustable linkage.

V. Water Level Control: Provide electric float switch.

W. Water Level Control: Provide electric float switch and solenoid makeup valve.

X. Flow Control Valves: Provide one of the following flow control valves for balancing flow to each distribution basin, and for shut-off during servicing:

1. Provide butterfly valves.
2. Provide globe valves.

Y. Fans and Drives: Provide one of the following fans and drives, installed by manufacturer.

1. Provide cast-aluminum propeller-fan of adjustable-pitch type.
2. Provide cast-aluminum propeller-fan of fixed-pitch type.

3. Provide galvanized steel propeller fan of fixed-pitch type.
    a. Provide gear-drive including speed reducer.
    b. Provide V-belt drives with sheave sized for rated air flow.

Z. Fans and Drives: Provide forward curved centrifugal fans with galvanized steel blades and V-belt drive with sheave sized for rated air flow.

AA. Fan Bearings: One of the following types installed by manufacturer:

1. Provide self-aligning ball bearings; include external extended grease lines, and fittings.
2. Provide bronze sleeve bearings with external oil lines, and fittings.

BB. Motor Type: Provide open drip-proof, energy efficient type motor.

CC. Motor Type: Provide totally enclosed, fan-cooled energy efficient type motor.

DD. Motor Type: Provide totally enclosed, air over, energy efficient type motor.

EE. Motor Speed: Provide single-speed motor rated at 1800 rpm.

FF. Motor Speed: Provide two-speed motor rated at 1800/900 rpm.

GG. Vibration Cutout Switch: Provide switch to de-energize fan motors if excessive vibration occurs due to fan imbalance.

HH. Discharge Damper Controls: Provide electric damper operator, controller, end switches, transformer, and weatherproof enclosure.

II. Assemble components by one of the following methods:

1. Use galvanized or stainless fasteners and accessories to assemble components.
2. Weld metal seams and joints.

JJ. Apply phosphatized pretreatment on zinc coated surfaces which have not been mill-phosphatized or polymer-coated. Apply gasoline-soluble rust preventative compound on ferrous parts which cannot be galvanized, including shafts and machined parts.

1. Finish components with zinc-coated metal surfaces by one of the following methods:
    a. Coat abraded areas and welded areas with galvanizing repair paint. Finish-paint exposed surfaces with zinc chromatized paint.
    b. Provide 2-1/4 oz. (per sq. ft. of sheet) zinc coating on basin and sump, after fabrication, by hot-dip galvanizing process. Coat abraded areas and welded areas of work with galvanizing repair paint.
    c. Apply to metal surfaces not galvanized, zinc-rich paint which has been tested and accepted by U.L. as being equivalent to hot-dipped galvanized steel.

KK. For polymer-coated surfaces, electrostatically spray with thermosetting hybrid polymer fuse-bonded to hot-dipped galvanized substrate during thermally activated curing stage. Provide polymerized metal surfaces that are capable of:

1. When "X" scribed to base substrate, withstand 6,000 hrs. of 5% salt spray test according to ASTM B 117, with no blistering or chipping around intersection of scribes, nor any undercutting or creepage along scribes.

2. When "X" scribed to base substrate, show no signs of chemical attach after 6,000 hrs. exposure in acidic (pH 4) and alkaline (pH 11) water solutions of 95o F (35o C).
3. When directly impacted with 160 in. lbs. from 0.625 in. radius impact tool, in accordance with ASTM D 2794, show no fracture or delamination.
4. When exposed to 6,000 hrs. of continuous ultraviolet exposure, equivalent to 120,000 hrs. of normal sunlight radiation, show no crackage.
5. When subjected to 200 thermal shock cycles between -25o and 180o deg F (-32 and 82o C), show no signs of deterioration.
6. When exposed continuously for 6,000 hrs. to high pressure (60 psig) water jet, show no signs of erosion.

LL. Maximum Permissible Sound Pressure Level: Use 0.0002 microbar as reference. Measure at 50 feet in several directions, uniformly covering 360 deg. Do not exceed maximum permissible dB level for each of the following standard center frequency octave bands:

| | |
|---|---|
| 63 hz-dB | 1000 hz-dB |
| 125 hz-dB | 2000 hz-dB |
| 250 hz-dB | 4000 hz-dB |
| 500 hz-dB | 8000 hz-dB |

MM. Vibration Control: Provide, as scheduled, one of the following types of vibration isolators, with number and size of isolators selected by manufacturer.

| | |
|---|---|
| Base Type A: | No base, isolators attached directly to equipment. |
| Isolator Type 1: | Pad, rubber or glass fiber. |
| Isolator Type 2: | Rubber floor isolator. |
| Isolator Type 4: | Restrained spring isolator. |

2.3 EJECTOR COOLING TOWERS:

A. General: Provide as indicated, factory-assembled and tested ejector cooling towers, of capacity as scheduled.

B. Air-Moving System: Design tower for forced draft without fans, motors, or other mechanical-electrical parts. Induce air into and through towers by water injection process.

C. Water Distribution System: Inject water and distribute uniformly through hot-dip galvanized steel spray tree consisting of header with built-in strainer, branches with provision for clean-out, and brass spray nozzles. Provide accessibility for entire water distribution system from front of unit, for inspection and servicing.

D. Pan Section: Construct pan section of hot-dip galvanized steel, finished with corrosion protection system. Fabricate depressed center sump in basin with connection for clean out and draining. Provide anti-vortexing device on suction connection, and large area hot-dip galvanized steel strainer screens, easily removable for cleaning.

E. Casing Section: Construct casing section of hot-dip galvanized steel, finished with corrosion protection system. Provide person-size access doors; and brass, float operated make-up valve complete with large diameter plastic float.

F. Inlet Air Stabilizers: Provide PVC inlet air stabilizers on intake side of unit, removable in easily handled sections to provide access to water distribution system.

G. Eliminators: Construct eliminators of PVC, mount in discharge air stream.

H. Discharge Louvers: Construct discharge louvers of hot-dip galvanized steel finished with corrosion protection system. Mount on discharge side of tower to direct air stream up and away from tower.

I. Strainer System: Provide double filtration system consisting of:

1. Large area, lift out, tray type, hot-dip galvanized steel strainer screens with perforated openings mounted in water sump, finished with corrosion protection system.
2. Large area, removable, hot-dip galvanized steel cylindrical strainer with perforations smaller than spray nozzle orifices mounted in spray header, finished with corrosion protection system. Provide blow-down connection at bottom of header/strainer assembly.

J. Corrosion Protection System: Prepare hot-dip galvanized steel by cleaning, pretreating, rinsing, and drying. Electrostatically spray with thermosetting hybrid polymer fuse-bonded to hot-dipped galvanized substrate during thermally activated curing stage. Provide polymerized metal surfaces that are capable of:

1. When "X" scribed to base substrate, withstand 6,000 hrs. of 5% salt spray test according to ASTM B 117, with no blistering or chipping around intersection of scribes, nor any undercutting or creepage along scribes.
2. When "X" scribed to base substrate, show no signs of chemical attack after 6,000 hrs. exposure in acidic (pH 4) and alkaline (pH 11) water solutions at 95o F (35o C).
3. When directly impacted with 160 in. lbs. from 0.625 in. radius impact tool, in accordance with ASTM D 2794, show no fracture or delamination.
4. When exposed to 6,000 hrs. of continuous ultraviolet exposure, equivalent to 120,000 hrs. of normal sunlight radiation, show no crackage.
5. When subjected to 200 thermal shock cycles between -25 and 180o F (-32 and 82o C), show no signs of deterioration.
6. When exposed continuously for 6,000 hrs. to high pressure (60 psig) water jet, show no signs of erosion.

K. Assembly: Assemble unit parts with phonelic-epoxy coated, cadmium-plated, washerhead fasteners.

L. Electric Immersion Heaters: Provide electric immersion heaters, factory-installed in cold water sump, of capacity and having electrical characteristics as scheduled. Provide control thermostat and low water cutout. Wiring to heaters; not work of this section.

M. Steam Heaters: Provide galvanized steam coil, factory- installed in cold water sump, of capacity as scheduled. Controls, valves, and traps; not work of this section.

N. Electric Water Level Control: Provide water level control consisting of magnetic type float switch in moisture proof housing, controlling solenoid valve with watertight housing located in make-up line to tower. Provide factory-set control that requires no field adjustment. Wiring to float switch and valve is not work of this section.

O. Pressure Gauges: Provide pressure gauges, complete with brass gauge cocks, mounted on water inlet connection and spray header assembly. Provide gauges with 4-1/2" face and 0 to 100 psi range.

2.4 CONDENSER WATER HOLDING TANKS:

A. General:

1. This Contractor shall complete the installation of [ ] [ ] condenser water holding tank(s), which shall be provided under Division 5. Detailed drawings shall be prepared by the Structural Engineer in cooperation with the Mechanical Engineer.
2. After the tank(s) have/has been fabricated, installed in the building and tested by Division 5, the Mechanical Contractor shall become responsible for the completion of the tank(s), including welding pipe to tank(s), pipe fittings, piping, valves, controls, accessories and lining as detailed on the drawings and as specified.

B. Lining: Tank(s) shall be lined by the fabricator, using applications of Wisconsin Protecting Coating Corp., "Plasite No. 7155," a total of ten (10) mils thick. Applications shall be in three coats in accordance with manufacturer's preparation and application instructions.

## PART 3 - EXECUTION

### 3.1 INSPECTION:

A. Examine areas and conditions under which factory-fabricated cooling towers are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

### 3.2 INSTALLATION:

A. General: Install cooling towers where indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, to ensure that cooling towers comply with requirements and serve intended purposes.

B. Level cooling towers to tolerance of 1/8" in 10'0", in both directions.

C. Access: Provide access and service space around and over cooling towers as indicated, but in no case less than that recommended by manufacturer.

D. Support: Install floor-mounted units on 4" high reinforced concrete pad, 6" larger on each side than cooling tower base. Cast anchor bolt inserts into pad.

OR

Support: Install roof-mounted units on structural steel mechanical equipment stand. Anchor cooling tower to stand with removable fasteners.

1. Construct mechanical equipment stand as indicated, and in accordance with NRCA Handbook and Accepted Roofing Knowledge, Detail "N".
2. Mechanical equipment stand is specified in Division 5; not work of this section.

E. Placement: Mount factory-fabricated cooling towers on vibration isolators if recommended by cooling tower and vibration isolation manufacturer. Install gaskets or sealants between cooling tower cells. Level units to tolerance of 1/8" in 10'-0", in both directions.

F. Mount ejector cooling tower on base using 5/8" minimum anchor bolts.

G. Condenser Water Piping: Provide flanged or union connections to cooling tower, with flexible pipe connections if tower is mounted on vibration isolators. Pitch lines so water will drain into sump. Connect inlets to cooling tower with shutoff valve, and balancing valve (if 2 or more inlets). Connect outlets with shutoff valves.

H. Make-up and Water Piping: Provide flanged or union connections to cooling tower, with flexible pipe connections if tower is mounted on vibration isolators. Pitch lines so water will drain into sump. Connect to automatic fill valve with 3-valve bypass, and backflow preventer.

I. Drain Piping: Connect drain, overflow, and bleed lines to cooling tower as indicated, full size of connection on cooling tower.

J. Mount pressure gauges, valves and controls furnished by manufacturer, in accordance with manufacturer's instructions.

K. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.3 ADJUSTING AND CLEANING:

A. Cleaning: Clean inside of cooling tower thoroughly before filling for start-up. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

B. Start-up: Comply with manufacturer's instructions for filling and start-up of operation, but not less than the following:

1. Verify lubrication of rotating parts; lubricate as needed.
2. Verify fan rotation direction.
3. Verify that motor amperage is in accordance with manufacturer's data.
4. Balance condenser water flow to each tower, and to each inlet for multiple inlet towers.
5. Adjust water level control for proper operating level.
6. Adjust bleed valve for indicated percentage of circulated water volume.
7. Balance equalizer lines between multiple towers (if any).
8. Adjust temperature controls and verify operation.

C. Operation Test: Test each cooling tower to show that it will operate in accordance with indicated requirements.

3.4 CLOSEOUT PROCEDURES:

A. Provide services of manufacturer's technical representative for one 8-hour day to instruct Owner's personnel in operation and maintenance of factory-fabricated cooling towers.

B. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.5 SPARE PARTS:

A. General: Furnish to Owner, with receipt, the following spare parts:

1. One spare set of matched fan belts for each belt driven fan.

2. Six spare spray nozzles with grommets for each tower cell.
3. One spare gasket for each gasketed access and inspection opening.
4. One valve seat for mechanical water make-up valve.
5. Two nozzle tie cables.
6. One final strainer screen with o-ring gasket.
7. One float ball.

**END OF SECTION 23 65 00**

# SECTION 23 73 00 – PACKAGED INDOOR HVAC UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of packaged heating and cooling units work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of packaged heating and cooling units specified in this section include the following:

1. Indoor packaged units, 15 tons and smaller.
2. Indoor packaged units, 20 tons and larger.
3. Variable air volume units.
4. Through-the-wall package units.

C. Refer to other Divisions 20 through 25 sections for automatic temperature controls not factory-installed, and required for conjunction with packaged heating and cooling units; not work of this section.

D. Electrical Work: Refer to Section 23 05 13 and Division 26 for requirements.

1.2 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants and environmentally friendly.

B. No CFC-based refrigerants shall be used.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged heating and cooling units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Provide capacity ratings for packaged heating and cooling units in accordance with ARI Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".
2. ASHRAE Compliance: Construct refrigerating system of packaged heating and cooling units in accordance with ASHRAE Standard 15 "Safety Code for Mechanical Refrigeration".
3. UL Compliance: Provide packaged heating and cooling units which are UL-listed and -labeled.

1.4 SUBMITTALS:

A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. The equipment provided shall provide the scheduled capacity when the substitute refrigerant proposed, the nominal equipment capacity reduction effects (if any), performance in KW/Ton, the refrigerant change out procedure and long term maintenance effects the new refrigerant has on the equipment.

B. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties and accessories; and installation and start-up instructions.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to packaged heating and cooling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of packaged heating and cooling units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field- installed.

E. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

F. Maintenance Data: Submit maintenance data and parts list for each packaged heating and cooling unit, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handle packaged heating and cooling units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged packaged heating and cooling units or components; replace with new.

B. Store packaged heating and cooling units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading packaged heating and cooling units, and moving units to final location for installation.

D. Units shall be broken down and shipped in components as field conditions require. A factory authorized representative shall inspect the final installation to certify that the unit has been reassembled per factory recommendations and specifications.

1.6 SPECIAL PROJECT WARRANTY:

A. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Extended Warranty Period: 5 years from Date of Final Completion and Acceptance.

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| This extended warranty is only applicable when the Owner has requested it and the associated costs have been determined and it has been documented in writing. This is not applicable to residential and smaller tonnage units. |

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Indoor Packaged Units:
    a. York; Division of York International
    b. Borg-Warner Air Conditioning, Inc.
    c. McQuay Air Conditioning; Snyder General Corp.
    d. The Trane Co.
    e. Mammoth
2. Variable Air Volume Units:
    a. York Division
    b. Borg-Warner Air Conditioning, Inc.
    c. McQuay Air Conditioning; Snyder General Corp.
    d. The Trane Co.
    e. Mammoth
3. Through-the-Wall Package Units:
    a. The Trane Co.
4. Outdoor Through-the-Wall Package Cooling and Heating Units:
    a. Climate-Tel
    b. Bard Manufacturing Co.

2.2 INDOOR PACKAGED UNITS, 15 TONS AND SMALLER:

A. General: Provide factory-assembled and tested packaged units as indicated, consisting of casing, compressor, evaporator, fans, filters, and unit controls. Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts. Insulate casing with 1/2" thick minimum thermal insulation, and compressor compartment with acoustical insulation. Provide knockouts for electrical and piping connections.

1. Provide decorative return air grille in return air opening.
2. Provide free discharge plenum over supply air opening, equipped with double deflection adjustable grilles.

C. Refrigeration Circuit: Provide refrigerant thermal expansion valve for refrigerant control. Provide access valves in suction and liquid lines. Provide dual refrigeration circuits for dual compressor units.

D. Compressors: Provide welded shell, hermetic compressors, 3,600 rpm; or serviceable hermetic compressors, 1750 rpm. Provide crankcase heaters.

1. Compressor shall be isolated within unit to prevent vibration.

E. Evaporator Coil: Construct of copper tubing and aluminum fins, pressure and leak tested at 1.5 times working pressure.

F. Fans: Provide double-inlet, forward curved, centrifugal fans with adjustable belt drive. Provide permanently lubricated fan and motor bearings, and thermal overloads in motor.

G. Filters: Provide 2" thick throwaway filters.

H. Water-Cooled Condensers: Provide shell-and-tube or tube- in-tube design with removable heads and cleanable tubes. Design for refrigerant side and water side pressures of 1.5 times working pressure, in accordance with ASME Pressure Vessel Code. Provide pressure relief valve, liquid line valve, and provisions for sub-cooling. Provide separate condenser for each refrigerant circuit.

I. Integral Air-Cooled Condensers: Provide condenser coil constructed of copper tubes and aluminum fins. Factory leak-test at 1.5 times working pressure, dehydrate and provide full charge of refrigerant. Provide sub-cooler and accumulator.

1. Condenser Fan: Provide double-width, double-inlet, forward-curved centrifugal fan with adjustable belt drive.
2. Low Ambient Control: Provide head pressure control, designed to operate at temperatures down to -20oF (-18 deg. C).

J. Remote Air-Cooled Condensers: Provide condenser coil constructed of copper tubes and aluminum fins. Factory leak-test at 1.5 times working pressure, dehydrate and provide full charge of refrigerant. Provide sub-cooler and accumulator. Provide propeller-type fan with adjustable belt drive.

1. Low Ambient Control: Provide head pressure control, designed to operate at temperatures down to 0 deg. F (- 18 deg. C).

K. Controls: Provide factory-installed and wired controls, with terminal strip. Provide connections for remote thermostat.

1. Provide each motor with individual overload protection.
2. Provide high and low refrigerant cutouts.
3. Provide fan-auto and heat-off-cool switches.
4. Dampers to accept 0-10 m/a signal
5. Low voltage controls

L. Heating Coil: Provide hot water heating coil, constructed of copper tubes and aluminum fins, designed to fit within casing with no duct modifications necessary.

2.3 INDOOR PACKAGED UNITS, 20 TONS AND LARGER:

A. General: Provide factory-assembled and tested packaged units as indicated, consisting of casing, compressors, evaporator, fans, filters, and unit controls. Provide capacities and electrical characteristics as scheduled.

B. Casings: Construct casings of 18-ga minimum mill galvanized steel, designed to withstand specific operating pressures. Provide casing panels and/or access doors that are easily and quickly removable for inspection and access to internal parts.

1. Provide single zone/variable air volume units consisting of fan section, coil section, adjustable fan motor mounting, and drain pan.
2. Provide multi-zone units consisting of single zone components, diffuser section, damper section, zoning dampers, and balancing plate when required to equalize resistances through cooling and heating passes.

3. Provide reinforced points of support for either setting or hanging units.
4. Provide drain pan, stainless steel located under cooling coil section and humidifier section, extensive enough to catch condensate leaving coil at highest catalogued face velocity. Provide at least one drain connection at low point in drain pan.
5. Cover casing and frame with protective finish on both sides.
6. Provide lights in accessible sections with wire guards, factory wired to switch mounted on casing exterior. In spray coil or humidifier sections provide marine lights of glass and wire sealed design.
7. Units shall be provided with double wall construction in fan section only/throughout. The interior section shall be constructed of 20 gauge, perforated sheet metal. The walls shall be 2"/4". The panels shall be fully insulated.

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| The above paragraph is for Temtrol, Pace, Mammoth or other custom type units only. It is not applicable to Trane, York and McQuay. |

8. The access doors shall be of double wall construction. Three lever type handles shall be provided on each access door. The doors shall be fully gasketed with neoprene material.
9. Provide decorative return air grille in return air opening.
10. Provide free discharge plenum over supply air opening, equipped with double deflection adjustable grilles.

C. Compressor: Reciprocating hermetic-type compressor, 1,750 RPM, designed for air-cooled condensing, complete with crankcase sight glass, crankcase heater, and back-seating service access valves on suction and discharge ports. Capacity shall be controlled through cylinder unloading. Additional features include:

1. Crankcase heater in well within crankcase;
2. Capacity steps as scheduled, or greater number;
3. Compressor of same manufacturer as condensing unit.

D. Screw Compressors:

E. Air-Cooled Condenser: Design unit for use with remote air-cooled condenser. Refer to Section 23 63 13 for specification requirements.

F. Water-Cooled Condenser: Provide shell-and-tube or tube-in- tube design with removable heads and cleanable tubes. Design for refrigerant side and water side pressures of 1.5 times working pressure, in accordance with ASME Pressure Vessel Code. Provide pressure relief valve, liquid line valve, and provisions for sub-cooling.

G. Cooling Coils: Construct of copper tubes mechanically expanded into aluminum fins. Test coils at 300 psig under water. Provide galvanized drain pan under coils. Provide for each coil, expansion valve, solenoid valve and distributor.

H. Heating Coils: Construct of copper tubes mechanically expanded into aluminum fins, with 18 ga. minimum galvanized steel casing. Test coils at 1.5 times working pressure.

I. Fan Sections: Provide forward curved/air foil/plug fans/backward inclined, fans specifically designed and suitable for class of service indicated. Provide adjustable motor base, adjusted with mounting bolts, to provide variation in center distance. Provide locking nuts, or similar devices, to secure base in proper position. Provide belt-driven fans with adjustable pitch pulley permitting fan speed to be varied. Select pulley for mid-point of adjustable range. Design fan shafts so as not to pass through first critical speed when unit comes up to rated RPM. Provide grease-lubricated fan bearings with externally accessible fittings for lubrication. Statically and dynamically balance fan assemblies in fan housing after final assembly.

1. Provide inlet vanes for stable capacity modulation where required for variable air volume applications. Discharge dampers shall not be an acceptable means to control fan capacity for variable air volume applications.
2. Fans shall be internally isolated on spring isolators. Flexible connectors shall be provided at all fan connections.
3. Where plug fans are provided, interlock access door with fan to turn fan off when door is opened.
4. Fan bearings shall be rated for a minimum of 200,000 hours.

J. Zoning Damper Sections: Provide zoning damper sections for multi-zone units, furnished with series of equal-sized discharge openings, each with set of dampers to regulate air flow from heating pass and cooling pass. Permanently secure damper blades in correct position on single shaft, rotating in sintered bronze or nylon bearings, and extend either upward or downward for connection to damper motor. Provide blade seals and edge seals on damper blades. Connect damper shafts together with one continuous linkage bar which may be cut in field to separate dampered openings into groupings as required. Provide damper section capable of either horizontal or vertical air discharge, factory-installed for orientation indicated.

K. Controls: Operating and safety controls shall include high and low pressure cutouts, oil pressure cutout, compressor winding thermostat cutout, 3-leg compressor overload protection, and condenser fan motors with thermal and overload cutouts. Control transformer if required shall be 115-volts. Provide magnetic contactors for compressor and condenser fan motors. Additional features include:

1. Reset relay circuit for manual resetting of cutouts from remote thermostat location;
2. Automatic non-recycling pump-down, and timing device to prevent excessive compressor cycling;
3. Unfused disconnect switch, factory-mounted and -wired, for single external electrical power connection.
4. Compressor shall be located in a section separated from condenser fans and coils.
5. Compressor shall be mounted on spring isolators.
6. Compressor shall be provided with hot-gas bypass

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| When HGBP is specified, make sure piping is shown on drawings. This is required when system capacity is anticipated; can be anticipated to drop to 30% or less. When in doubt, it should be provided. |

7. Extended 5-year compressor warranty: 5 years from date of Final Completion.

L. Temperature Controls: Provide remote thermostat for heat, fan, and cool control.

M. Temperature Control: Provide sensor unit, factory-mounted in supply plenum to actuate compressor cylinder unloaders through slow-acting step controller.

1. Economizer Control: Provide factory-installed and wired enthalpy control of outside and return air dampers, interlocked with plenum sensor unit.
2. Timeclock: Provide programmable 7-day time-clock to index system between occupied and unoccupied cycles, and to actuate morning warm-up cycle when conditions require.

N. Multi-Zone Controls: Control compressor loading and unloading from leaving cooling coil temperature. Provide hot-gas bypass control on last step.

O. Filters: Provide filter box with integral filter rack and hinged access door on both sides.

Filter Type: 2"/4" thick throwaway.
Filter Type: 2"/4" thick permanent.
Filter Type: 1"/2"/4" thick, UL Class 2, pleated media @ 20%/30% efficiency when tested in accordance with ASHRAE 52-7 standard.

P. Mixing Boxes: Provide mixing boxes of physical size to match basic unit, and include equal-sized flanged openings capable of handling full air flow. Arrange openings as indicated. Provide dual action parallel dampers with blade seals and edge seals, arranged to operate automatically with one set of linkage. Provide dampers of balanced construction, rotating in sintered bronze or nylon bearings.

1. Provide dampers with leakage limited to 10 cfm/sq. ft. at 4" w.g.
2. Dampers shall be aluminum, air foil type dampers.

| Air foil dampers are not available on Trane, York, McQuay. Edit as required. |
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2.4 VARIABLE AIR VOLUME UNITS:

A. General: Provide factory-assembled and tested packaged variable air volume units as indicated, consisting of casing, compressors evaporator, fans, filters, and unit controls. Provide capacities and electrical characteristics as scheduled.

B. Casings: Construct casings of 18-ga minimum mill galvanized steel, designed to withstand specific operating pressures. Provide casing panels and/or access doors that are easily and quickly removable for inspection and access to internal parts.

1. Provide single zone/variable air volume units consisting of fan section, coil section, adjustable fan motor mounting, and drain pan.
2. Provide multi-zone units consisting of single zone components, diffuser section, damper section, zoning dampers, and balancing plate when required to equalize resistances through cooling and heating passes.
3. Provide reinforced points of support for either setting or hanging units.
4. Provide drain pan, stainless steel located under cooling coil section and humidifier section, extensive enough to catch condensate leaving coil at highest catalogued face velocity. Provide at least one drain connection at low point in drain pan.
5. Cover casing and frame with protective finish on both sides.
6. Provide lights in accessible sections with wire guards, factory wired to switch mounted on casing exterior. In spray coil or humidifier sections provide marine lights of glass and wire sealed design.
7. Units shall be provided with double wall construction in fan section only/throughout. The interior section shall be constructed of 20-gauge, perforated sheet metal. The walls shall be 2"/4". The panels shall be fully insulated.

The above paragraph is for Temtrol, Pace, Mammoth or other custom type units only. It is not applicable to Trane, York and McQuay.

8. The access doors shall be of double wall construction. Three lever type handles shall be provided on each access door. The doors shall be fully gasketed with neoprene material.
9. Provide decorative return air grille in return air opening.
10. Provide free discharge plenum over supply air opening, equipped with double deflection adjustable grilles.

C. Compressor: Reciprocating hermetic-type compressor, 1,750 RPM, designed for air-cooled condensing, complete with crankcase sight glass, crankcase heater, and back-seating service access valves on suction and discharge ports. Capacity shall be controlled through cylinder unloading. Additional features include:

1. Crankcase heater in well within crankcase;
2. Capacity steps as scheduled, or greater number;
3. Compressor of same manufacturer as condensing unit.

D. Screw Compressors:

E. Air-Cooled Condenser: Design unit for use with remote air-cooled condenser; not work of this section. Refer to Section 23 63 13 for specification requirements.

F. Water-Cooled Condenser: Multi-pass shell-and-tube type condenser having replaceable seamless integral finned copper tubes, positive liquid sub-cooling circuit, pressure relief device, liquid level test cock, purge connection, liquid line shutoff valve, and 1/4" flare angle valve for connection of water regulating valve.

1. Unit shall bear ASME stamp for refrigerant side working pressure of 385 psig; and water side working pressure of 250 psig.

G. Cooling Coils: Provide nonferrous construction with aluminum fins mechanically bonded to copper tubing. Provide capacity control of refrigerant flow to coils, capable of modulating to 10% of nominal capacity.

H. Heating Coils: Provide nonferrous construction with aluminum fins mechanically bonded to copper tubing. Provide 18-ga. minimum galvanized steel casing.

I. Fan Sections: Provide forward curved/air foil/plug fans/backward inclined, fans specifically designed and suitable for class of service indicated. Provide adjustable motor base, adjusted with mounting bolts, to provide variation in center distance. Provide locking nuts, or similar devices, to secure base in proper position. Provide belt-driven fans with adjustable pitch pulley permitting fan speed to be varied. Select pulley for mid-point of adjustable range. Design fan shafts so as not to pass through first critical speed when unit comes up to rated RPM. Provide grease-lubricated fan bearings with externally accessible fittings for lubrication. Statically and dynamically balance fan assemblies in fan housing after final assembly.

1. Provide inlet vanes for stable capacity modulation where required for variable air volume applications. Discharge dampers shall not be an acceptable means to control fan capacity for variable air volume applications.
2. Fans shall be internally isolated on spring isolators. Flexible connectors shall be provide at all fan connections.

3. Where plug fans are provided, interlock access door with fan to turn fan off when door is opened.
4. Fan bearings shall be rated for a minimum of 200,000 hours.

J. Filters: Provide filter box with integral filter rack and hinged access door on both sides.

Filter Type: 2"/4" thick throwaway.
Filter Type: 2"/4" thick permanent.
Filter Type: 1"/2"/4" Pleated media @ 20%/30% ASHRAE atmospheric dust spot efficiency.

K. Controls: Operating and safety controls shall include high and low pressure cutouts, oil pressure cutout, compressor winding thermostat cutout, 3-leg compressor overload protection, and condenser fan motors with thermal and overload cutouts. Control transformer if required shall be 115 volts. Provide magnetic contactors for compressor and condenser fan motors. Additional features include:

1. Reset relay circuit for manual resetting of cutouts from remote thermostat location;
2. Automatic non-recycling pump-down, and timing device to prevent excessive compressor cycling;
3. Unfused disconnect switch, factory-mounted and wired, for single external electrical power connection.

L. Temperature Control: Provide sensor unit, factory-mounted in supply plenum to actuate compressor cylinder unloaders through slow-acting step controller.

1. Economizer Control: Provide factory-installed and -wired enthalpy control of outside and return air dampers, interlocked with plenum sensor unit.
2. Time-clock: Provide programmable 7-day time-clock to index system between occupied and unoccupied cycles, and to actuate morning warm-up cycle when conditions require.
3. Provide hot-gas bypass.

M. Mixing Boxes: Provide mixing boxes of physical size to match basic unit, and include equal-sized flanged openings capable of handling full air flow. Arrange openings as indicated. Provide dual action parallel dampers with blade seals and edge seals, arranged to operate automatically with one set of linkage. Provide dampers of balanced construction, rotating in sintered bronze or nylon bearings.

1. Provide dampers with leakage limited to 10 cfm/sq. ft. at 4" w.g.
2. Dampers shall be aluminum, air foil type dampers.

| Air foil dampers are not available on Trane, York, McQuay. Edit as required. |
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2.5 THROUGH-THE-WALL PACKAGED HEATING AND COOLING UNITS:

A. General: Provide packaged heating and cooling units as indicated, consisting of cabinet compressor, evaporator fan condenser fan, filters, wall sleeve, louver, sub-base, coils and controls. Provide capacities and electrical characteristics as scheduled.

B. Cabinet: Wall sleeve and unit chassis shall be 18-gauge, phosphatized, galvanized steel. Exterior parts shall be hot dipped, zinc-coated. Bulkhead shall be insulated. The entire chassis shall be primed and painted, electrically bonded to the metal and baked on. Wall sleeve and room cabinet shall be baked-on acrylic enamel. The front panel of the unit chassis shall be removable. Provide sub-base.

C. Louver: The exterior louver shall be extruded aluminum.

D. Grille: Grille shall be adjustable discharge at an angle of 15 or 40 degrees from vertical position.

E. Fans: Evaporator fan shall be twin, forward curved, centrifugal type, direct connected to a two-speed motor. Condenser fan shall be propeller type.

F. Controls: Provide unit mounted push-button controls with the following functions:

1. OFF - Turns unit off.
2. FAN ONLY - Indoor fan operates at medium speed.
3. HI-COOL - Provides cooling with medium-speed indoor fan.
4. LO-COOL - Provides cooling with low-speed indoor fan.
5. HI-HEAT - Provides heating with medium-speed indoor fan.
6. LO-HEAT - Provides heating with low-speed fan.
7. LOW AMBIENT LOCKOUT - Prevents compressor from running below 40oF outdoor ambient.

Provide unit with a factory-mounted terminal strip to be tied into a remote wall-mounted 24-volt thermostat.

G. Outside Air Damper: Provide adjustable manual outside air damper for zero outside air (closed) to fully open (60%).

H. Fan Cycle Switch: Provide fan switch to allow either continuous or cycled fan control.

I. Refrigeration System: Compressor shall be fully hermetic, internally isolated with a steel shell and externally isolated. Tubing connections to compressor shall be looped.

J. Capillary Tube Expansion Device: Provide capillary tube expansion device for uniform refrigerant flow throughout the system operating range to maintain operating efficiency.

K. Coils: Coils shall be seamless copper tubing mechanically expanded into configured aluminum plate fins and tested at 600 psi.

Heat Pump Type Unit: Heat pump type units shall be provided with a reversing valve which locks in the reverse cycle position, as long as controls are in the "heat" position, to prevent noisy feedback when the unit shuts off. A coil thermostat senses outdoor coil temperature during heating operation and switches unit from reverse cycle operation to electric heat when outdoor air temperature can lead to frost formation on the outdoor coil.

L. Electric Heating Coils: Nichrome coiled elements protected by a fusible link and an overheat limit control. Coils 4.0 kw or greater have two-stage operation.

M. Motors: Provide separate evaporator and condenser fan motors. Motors shall be high efficiency, permanent split capacitor (psc) type.

N. Electrical: Provide units with factory-installed cord or detach cord for permanent wiring connection to the unit.

For use with hard-wire junction box. Provide mechanical disconnect at the junction box.

O. Leveling Legs: Provide adjustable leveling legs for adjustment from 2-5/8" to 5-1/4".

Provide factory-supplied, field installed, package for central system hot water heat/steam capability at the unit. Optional package includes hydronic coil box, auxiliary control escutcheon, transition piece and control valve wiring harness. Coil is of seamless copper tubing, mechanically expanded into configured aluminum plate fins, one-row coil, 3/8" tube, 13 fins per inch and air bleed port. Left-handed or right-handed female connections and tested at 300 psi.

P. Thermostats: For use with remote thermostat controlled unit, provide the following:

1. Single-speed fan operation in heating and cooling mode.
2. Two-speed fan operation in heating and cooling mode.
3. Provide lock to control panel access to prevent unauthorized operation.
4. Provide set back thermostat with manual override.

2.6 OUTDOOR THROUGH-THE-WALL PACKAGED COOLING AND HEATING UNITS:

A. General: Provide factory-assembled and tested packaged units as indicated, consisting of casing, compressor, evaporator, fans, filters, wall sleeves, grilles with knurled thumb screws, unit controls, coils, outside air intake hood with filter, energy conservation system and remote mounted thermostat. Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels and/or access doors for inspection and access to internal parts. Insulate casing with 1/2" thick minimum thermal insulation, and compressor compartment with acoustical insulation. Provide knockouts for electrical and piping connections.

1. Provide double deflection supply air and single deflection return air grilles in extended wall sleeve openings.

C. Refrigeration Circuit: Provide refrigerant thermal expansion valve for refrigerant control. Provide access valves in suction and liquid lines. Provide dual refrigeration circuits for dual compressor units.

D. Compressors: Provide welded shell, hermetic compressors, 3,600 rpm; or serviceable hermetic compressors, 1750 rpm. Provide crankcase heaters.

E. Evaporator Coil: Construct of copper tubing and aluminum fins, pressure and leak tested at 1.5 times working pressure.

F. Fans: Provide double-inlet, forward curved, centrifugal fans with adjustable belt drive. Provide permanently lubricated fan and motor bearings, and thermal overloads in motor.

G. Filters: Provide 2" thick, 30% efficiency throwaway filters.

H. Integral Air-Cooled Condensers: Provide condenser coil constructed of copper tubes and aluminum fins. Factory leak-test at 1.5 times working pressure, dehydrate and provide full charge of refrigerant. Provide sub-cooler and accumulator.

1. Condenser Fan: Provide double-width, double-inlet, forward-curved centrifugal fan with adjustable belt drive.
2. Low Ambient Control: Provide head pressure control, designed to operate at temperatures down to 0oF (-18oC).

I. Electric Resistance Coils: Open-wire type, 80 percent nickel, 20 percent chromium. Elements shall be uniformly distributed over cross-sectional area of unit with vertical support brackets to prevent coil element sag. Coil elements shall be insulated with ceramic bushings and supported in an aluminized or galvanized steel frame.

OR

Electric Resistance Coils: Finned-tubular construction with 80 percent nickel, 20 percent chromium. Elements shall be mounted in oxide powder. Tubes shall be spirally wound with copper-plated steel fins that are continuously brazed to tubes. Coils shall be mounted in an aluminized or galvanized steel frame.

J. Controls: Provide factory-installed and wired controls, with terminal strip. Provide connections for remote thermostat.

1. Provide each motor with individual overload protection.
2. Provide high and low refrigerant cutouts.
3. Provide on-off and off-cool switches.

PART 3 - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which packaged heating and cooling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF PACKAGED HEATING AND COOLING UNITS:

A. General: Install packaged heating and cooling units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support: Install units on 4" high concrete pad, 4" larger on each side than equipment base. Cast anchor bolt inserts into pad.

C. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
2. Ductwork: Refer to Section 23 31 00 "Ductwork". Connect supply and return ducts to unit with flexible duct connections. Provide transitions to exactly match unit duct connection size.
3. Connect all duct connections to unit with flexible connection, provide manual damper, quadrant and lock.

D. Water-Cooled Condenser Piping: Refer to Section 23 21 16 "Hydronic Specialties". Connect supply and return piping to unit as indicated, with unions and shutoff valves.

E. Air-Cooled Condenser Piping: Refer to Section 23 21 16 "Hydronic Specialties". Connect liquid and hot gas piping to unit as indicated.

F. Hot Water Heating Coil Piping: Refer to Section 23 21 16 "Hydronic Specialties". Connect supply and return piping to hot water coil as indicated, with unions, flexible connections, balancing valves, thermometers (supply and return), P & T taps (supply and return), shutoff valves and other accessories.

G. Steam Heating Coil Piping: Refer to Section 23 22 16 "Steam Specialties". Connect steam and condensate piping in steam coil as indicated, with unions and shutoff valves.

H. Drain Piping: Connect unit drain to nearest indirect waste connection. Provide trap at drain pan; construct at least 1" deeper than fan pressure in inches of water.

3.3 FIELD QUALITY CONTROL:

A. General: Start-up packaged heating and cooling units, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

3.4 TRAINING:

A. Schedule a minimum of 4 hours of training with Owner. The manufacturer’s representative and the installing contractor shall be present. The training shall be coordinated by the installing contractor, General Contractor, Architect/Engineer and the Owner in conjunction with the other mechanical equipment on the project.

B. Training:

1. Train Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel the contents of the Operating and Maintenance Data specified in the LPS General Conditions of the Contract and Section 23 05 00.
2. Schedule training with Owner through the Architect/Engineer with at least 7 days’ prior notice.

3.5 SPARE PARTS:

A. General: Furnish to Owner, with receipt, the following spare parts for each packaged heating and cooling unit:

1. One set of matched fan belts for each belt driven fan.
2. One set filters for each unit.

**END OF SECTION 23 73 00**

# SECTION 23 74 00 – PACKAGED ROOFTOP HVAC UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of packaged rooftop heating and cooling units work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Divisions 23 through 25 sections for metal ductwork, air devices, automatic temperature controls not factory-installed, and required for conjunction with packaged heating and cooling units; not work of this section.

C. Electrical Work: Refer to Section 23 05 13 and Division 26 for requirements.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, dimensions, required clearances, weights, furnished specialties and accessories; and installation and start-up instructions.

B. Shop Drawings:

1. Submit shop drawings detailing the manufacturer's electrical requirements for power supply wiring for rooftop heating and cooling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

2. Submit shop drawings detailing the mounting, securing, and flashing of the roof curb to the roof structure. Indicate coordinating requirements with roof membrane system.

C. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

D. Maintenance Data: Submit maintenance data and parts list for each rooftop heating and cooling unit, control, and accessory, including "trouble- shooting" maintenance guide. Include this data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of rooftop heating and cooling units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. Gas-fired furnace section construction shall be in accordance with AGA safety standards. Furnace section shall bear the AGA label.

2. Testing and rating of rooftop units of 135,000 btu/hr capacity or over shall be in accordance with ARI 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".

3. Testing and rating of rooftop units under 135,000 btu/hr capacity shall be in accordance with ARI 210 "Standard for Unitary Air-Conditioning Equipment", and provide Certified Rating Seal. Sound testing and rating of units shall be in accordance with ARI 270

"Standard for Sound Rating of Outdoor Unitary Equipment". Units shall bear Certified Rating Seal.

4. Refrigerating system construction of rooftop units shall be in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

5. Energy Efficiency Ratio (EER) of rooftop units shall be equal to or greater than prescribed by ASHRAE 90A "Energy Conservation in New Building Design".

6. Provide rooftop units which are UL-listed and -labeled.

7. Rooftop units shall be designed, manufactured and tested in accordance with UL requirements.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle rooftop units and components carefully to prevent damage. Replace damaged rooftop units or components with new.

B. Store rooftop units and components in clean dry place, off the ground, and protect from weather, water and physical damage.

C. Rig rooftop units to comply with manufacturer's rigging and installation instructions for unloading rooftop units and moving them to final location.

1.5 SCHEDULING AND SEQUENCING:

A. Coordinate installation of roof mounting curb with roof structure.

B. Coordinate roof opening locations and for mechanical and electrical connections.

1.6 SPECIAL WARRANTY:

A. Warranty on Compressor and Heat Exchanger: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, compressors and heat exchangers with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from date of Final Completion.

1.7 MAINTENANCE:

A. Extra Materials: Furnish to Owner, with receipt, the following spare parts for each rooftop heating and cooling unit:

1. One set of matched fan belts for each belt-driven fan.

2. One set filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Rooftop Units:
   a. Carrier
   b. Lennox Industries
   c. McQuay Air Conditioning Group; McQuay Inc.
   d. The Trane Co; Div of American Standard Inc.
   e. York; Div of York International.

2. Make Up Air Units:
   a. McQuay
   b. Reznor
   c. Captive Aire
   d. Sterling
   e. Trane
   f. Aaon

2.2 ROOFTOP UNITS (3 TO 50 TONS):

ENGINEER NOTE: Written around a Trane Voyager unit, 3 to 50 tons. Units 27-1/2 tons and greater can be delivered with VAV, hydronic coils and other special options. These options are not covered by this specification.

A. General Description: Units shall be factory-assembled and tested, designed for roof or slab installation, and consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, condenser coil guards and dampers. Capacities and electrical characteristics are scheduled on the Drawings.

B. Casing: Manufacturer's standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1/2" thick thermal insulation, knockouts for electrical and piping connections and an exterior condensate drain connection and lifting lugs.

C. Roof Curbs: Manufacturer's standard construction, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple. Construction shall be in accordance with NRCA Standards.

1. Provide ¾” rubber waffle vibration isolation and around full curb perimeter.

OR

Provide full perimeter spring isolation rail.

OR

Provide rubber gasket around full curb perimeter.

D. Evaporator Fans: Forward-curved, centrifugal, belt-driven fans with adjustable sheaves or direct-driven fans; and permanently lubricated motor bearings.

E. Condenser Fans: Propeller-type, direct-driven fans with permanently lubricated bearings.

F. Coils:

1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of

the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.

ENGINEER NOTE: Steam/water coils not a factory option on smaller packaged units. Call representative for exact cutoff.

2. Steam Heating Coils: Non-freeze steam coils, pitched in unit casing for proper drainage Coils shall be double tube type having accurately sized steam distributor tubes and evenly spaced orifices. Orifices shall discharge steam in the direction of condensate flow to ensure even distribution of steam over full length of each tube. Coils shall be proof- (150 psig) and leak-tested (100 psig) with air pressure under water.

OR

3. Water Heating Coils: Pitched in the unit casing for proper drainage. Coils shall have metering orifices and a supply header to ensure distribution of hot water to each tube. Coils shall be proof (300 psig) and leak (200 psig) tested with air pressure under water continuous tube type, and proof- (300 psig) and leak-tested (200 psig) with air pressure under water.

4. Refrigerant Cooling Coils: Have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be proof- (450 psig) and leak-tested (300 psig) with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.

G. Compressors: Serviceable, semi-hermetic, or fully hermetic compressors, complete with integral vibration isolators and crankcase heaters.

H. Safety Controls: Manual reset type for:

1. Low pressure cutout;
2. High pressure cutout;
3. Compressor motor overload protection.

I. Heat Exchangers: Manufacturer's standard construction for gas-fired heat exchangers and burners.

1. Controls:
   a. Redundant gas valve;
   b. Intermittent pilot ignition;
   c. Electronic spark ignition system;
   d. High limit cutout;
   e. Forced draft proving switch.
   f. Dampers to accept 0-10 m/a signal
   g. Low voltage control

J. Economizer Control: Return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control and adjustable mixed-air thermostat. System shall have 100% outside air capability. Provide automatic changeover through adjustable enthalpy control device.

ENGINEER NOTE: For Trane, VAV only at and above 27-1/2 tons.

M. Variable Air Volume Control: Discharge air step controller, and electric control system with enthalpy control.

N. Electric Heat Sections: Electric heat coils, of manufacturer's standard construction, factory-wired for single point wiring connection, complete with over-current and over-heat protection devices.

O. Accessories: Units shall include the following accessories as indicated or scheduled:

1. See schedules on drawings for additional requirements.

ENGINEER NOTE: Low ambient control not needed with 100% economizer.

2. Low ambient control: Furnish low ambient control for head pressure control, designed to operate at temperatures down to 0° F (-18° C).

3. Thermostat: Assembly shall provide for staged heating and cooling with manual or automatic changeover on standard sub-base.

4. Anti-Recycling Control: Furnish anti-recycling control to automatically prevent compressor restart for 5 minutes after shutdown.

5. Provide hail guards.

2.3 ROOFTOP UNITS (20 TONS TO 130 TONS):

ENGINEER NOTE: Written around Trane Intellipak.

A. General Description: Rooftop unit shall be factory- assembled and tested, designed for roof or slab installation and, consisting of compressors, condensers, evaporator coils, condenser and evaporator fans, refrigeration and temperature controls, filters, and dampers. Capacities and electrical characteristics are scheduled on the Drawings.

B. Casing manufacturer's standard casing construction, having corrosion protection coating, and exterior finish. Casings shall have removable panels or access doors for inspection and access to internal parts, a minimum of 1" thick thermal insulation on double wall and ½" thick on single wall. Provide knockouts for electrical and piping connections, and an exterior condensate drain connection, and lifting lugs.

C. Roof curbs: Manufacturer's standard construction, insulated and having corrosive protective coating, complete with factory-installed wood nailer and drain nipple. Construction shall be in accordance with NRCA Standards.

1. Pedestal curbs are not acceptable for jurisdictions; if so, provide full perimeter curb.

OR

Provide full perimeter curb with pedestal beam for DX air cooled condensing unit.

2. Provide ¾" rubber waffle vibration isolation pad around full curb perimeter, to fully

OR

Provide full curb perimeter spring isolation rail.

OR

Provide rubber gasket around full curb perimeter.

D. Exhaust and Supply Air Fans: Forward-curved or airfoil, centrifugal, belt-driven fans with adjustable sheaves; and permanently lubricated motor bearings.

E. Condenser fans: Propeller-type, direct-driven fans with permanently lubricated bearings.

F. Coils:

1. General: Aluminum plate fin and seamless copper tube type. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing. Coils shall be mounted in the coil casing with same end connections accessible for service. Coils shall be removable from the unit through the roof or through the piping enclosure. Coil section shall be completely insulated.

2. Steam Heating Coils: Non-freeze steam coils, pitched in unit casing for proper drainage. Coils shall be double tube type having accurately sized steam distributor tubes and evenly spaced orifices. Orifices shall discharge steam in the direction of condensate flow to ensure even distribution of steam over full length of each tube. Coils shall be proof (150 psig) and leak (100 psig) tested with air pressure under water.

OR

Water Heating Coils: Pitched in the unit casing for proper drainage. Coils shall have metering orifices and a supply header to ensure distribution of hot water to each tube. Coils shall be proof (300 psig) and leak (200 psig) tested with air pressure under water. Continuous tube type, and proof (300 psig) and leak (200 psig) tested with air pressure

3. Refrigerant Cooling Coils: Have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant. Coils shall be proof (450 psig) and leak (300 psig) tested with air pressure under water, then cleaned, dehydrated, and sealed with a holding charge of nitrogen.

4. Electric heat sections: Manufacturer's standard construction electric heat coils, factory-wire for single point wiring connection. Complete with over-current and over-heat protection devices.

G. Compressors: Scroll type, serviceable, semi-hermetic, or hermetic compressors with integral vibration isolators, and crankcase heaters which de-energize during compressor operation. Units shall also have:

a. Hot-gas bypass valve and piping on one compressor.

b. Thermal expansion valves, filter dryers, sight glasses, compressor service valves, liquid line service valves; minimum of 2 refrigerant circuits for units having 2 or more compressors; and fan-cycling control for low ambient control to 35$^{o}$ F (2$^{o}$ C).

ENGINEER NOTE: Low ambient only when no economizer.

H. Safety Controls:

1. Low pressure cutout, manual reset;
2. High pressure cutout, manual reset;
3. Compressor motor overload protection, manual reset;

4. Anti-recycling timing device;
5. Adjustable low-ambient lockout;
6. Oil pressure switch.
7. Supply duct over-pressurization

I. Heat Exchangers: Manufacturer's [standard] [stainless steel] construction for gas-fired heat exchangers and burners, designed for minimum of [2-stage operation] [3:1 modulation] [4:1 modulation]. Provide single gas connection.

ENGINEER NOTE: Trane with 4:1 modulation is very expensive.

1. Controls:
   a. redundant gas valves;
   b. intermittent pilot ignition;
   c. electronic spark ignition system;
   d. high limit cutout;
   e. forced draft proving switch;
   f. flame roll-out switch.

J. Economizer Control: Return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control, and adjustable mixed-air thermostat. System shall have 100% outside air capability. Provide automatic changeover through adjustable enthalpy control device.

K. Variable Air Volume Control: Discharge air step controller, electric control system with enthalpy control, and 7-day programmable time clock.

L. Filters Section: 2" thick fiberglass throwaway filters in filter rack, with maximum face velocity of 300 fpm.

M. Electrical: Units shall have a 115 VAC convenience outlet, separately fused, for unit service. Unit power connection shall be either through unit cabinet or within roof curb perimeter. Provide UL-listed disconnect switch.

N. Temperature Control: Factory-installed, demand-oriented solid-state control system with minimum of 2 cooling steps and 2 heating steps. Controls shall include solid-state thermostats with dead-band, and sub-base with system and fan switches. Other control features include:

1. Discharge temperature reset capability with space temperature override;

2. 7-day programmable time clock, with power failure carryover, for remote mounting;

3. Warm-up cycle;

4. Provide [outdoor air damper compensation control package] [IAQ dampers and flow monitoring station] for minimum outside air volume control during VAV modulation.

O. Accessories: Units shall include the following accessories as indicated or scheduled:

1. Remote Control Panel: Furnish panel for remote mounting containing control of heating, cooling, evaporator fan, and outdoor damper; and indicator lights for up to 6 unit functions.

2. Anti-Recycling Control: Furnish anti-recycling control to automatically prevent compressor restart for 5-minutes after shutdown.

3. Low Ambient Control: Furnish anti-recycling control for head pressure control, designed to operate at temperatures down to 0° F (-18° C).

ENGINEER NOTE: Not needed with economizer.

4. Thermostat: Assembly shall provide for staged heating and cooling with manual or automatic changeover on standard sub-base.

5. High duct temperature shutdown.

6. Provide hail guards.

7. See schedules and drawings for additional required accessories.

2.5 MAKE-UP AIR UNITS:

ENGINEER NOTE: Written around Reznor unit.

General: Provide factory-fabricated and factory-tested air handling units as indicated, or sizes and capacities as scheduled, and as specified herein.

A. Components:

1. [Evaporative Cooling Section] [Chilled Water Coil Section]
2. Filters
3. Supply Fan, Motors & Drive
4. [Furnace Section] [Heating Water Coil Section]
5. Controls

B. Cabinet:

1. Factory painted enamel finish
2. Insulate walls and roof of cabinet
3. Include lifting lugs welded or bolted to the base of unit
4. Hinged and latched fan access door
5. Fan cabinet shall be [horizontal duct outlet] [down discharge plenum outlet]

C. Fan:

1. Centrifugal fans with forward curved or backward inclined blades, AMCA-certified
2. Motors shall be high-efficiency, meeting criteria of Section 23 05 13.
3. Motor sheaves and drive belts shall be sized to eliminate belt squeal on start-up.
4. Filter rack with 2” 30%-efficient pleated filters, factory-installed.

D. Furnace Sections:

1. [Direct fired gravity vented] [Indirect fired power vented]
2. Heat exchanger shall be 409 stainless steel
3. Burners shall be 409 stainless steel
4. Furnace sections shall be equipped with the following safety and limit controls:
   a. Redundant gas valve
   b. Intermittent spark safety pilot
   c. Differential air pressure switch
   d. Electronic modulating gas control valves
   e. Fire stat
   f. Gas pressure safety switch

g. Air flow proving switch
h. The packaged make-up air system shall be certified and bear the label of AGA.

E. Direct Evaporative Cooling Section:

1. Evaporative cooling section which shall have a saturation effectiveness of 90%. Utilize 12" CELDEK or equal.
2. Stainless steel sump
3. Make-up water float valve
4. Centrifugal type spray pump, thermally protected
5. Type L copper piping header
6. Automatic fill and drain kit.
7. Sump-less water spray evaporative coolers with media moisture sensors also acceptable.

F. Controls:

1. Provide factory control module to provide the start/stop function of the unit, interlocks to kitchen hoods and meet the Sequence of Operation.
2. Provide supply water and sump drain down kits for freeze protection. This includes all required piping, control valves and control wiring.

G. Options:

1. Factory roof curb with [full perimeter rubber gasket] [full perimeter ¾" waffle vibration isolation]
2. Inlet dampers, with two-position control actuator.
3. 2" thick 30% filters.
4. Fresh air inlet hood with birdscreen.
5. See schedules for additional accessories

2.6 MAKE-UP AIR UNITS (DX COOLING):

ENGINEER NOTE: Written around Aaon unit.

Unit Performance:

1. Unit cooling capacities shall be in accordance with and tested to ARI standard 210/240-89 or 360-85.
2. Units shall carry the ARI compliance label.
3. Units shall be safety certified in accordance with UL Standard UL 1995, and ANSI Standard Z21.47.
4. Unit shall be 100% run tested by the manufacturer with a copy of the run test report shipped with the unit.

B. Unit Construction:

1. Unit design shall be dedicated bottom supply/return air style system for mounting on a roof curb.
2. Cabinet shall be constructed entirely of G90 galvanized metal with the exterior constructed of 18 gauge or heavier material.
3. Access to compressor(s), controls, filter, blower, heating section and other items needing periodic checking or maintenance shall be through hinged access doors with a quarter turn latch (door fastening screws are not acceptable). Air side service access doors shall be fully gasketed with rain break overhangs.
4. Unit exterior shall be painted with polyurethane paint over a primer and a G90 type galvanized steel.
5. The interior air side of the cabinet shall be entirely insulated on all exterior panels with 1" thick, 1.5 pound density, neoprene coated, fiberglass insulation.

C. Blowers:

1. Blower(s) shall be entirely self-contained on a slide deck for service and removal from the cabinet.
2. All belt drive blower(s) shall have backward inclined airfoil blades.
3. Blower, drives and motors shall be dynamically balanced.

D. Outside Air:

1. Shall be a modulating enthalpy controlled 100% economizer with multi-stage integrated economizer and compressor operation for maximum benefit. The economizer shall consist of a motor operated outdoor air damper and return air damper constructed of extruded aluminum, hollow core, air foil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 25 CFM of leakage per square foot of damper area when subjected to 2" WG air pressure differential across the damper. Damper motor shall be spring return to ensure closing of outdoor air damper during periods of unit shut down or power failure. A pressure relief damper sized for 100% relief air shall be provided as part of the economizer.

E. Power Exhaust:

1. The control shall be on-off and all controls shall be factory-installed.

F. Evaporator Coil:

1. Evaporator coil(s) shall be copper tube with aluminum fins mechanically bonded to the tubes.
2. Evaporator coils to have galvanized steel end casings.
3. Evaporator coils for multi-compressor units shall be circuited with one circuit and expansion valve per compressor.

G. Condenser Coil:

1. Condenser coil(s) shall be copper tube with aluminum fins mechanically bonded to tubes.
2. Provide hail guards.

H. Refrigeration System:

1. Compressor(s) shall be of the hermetic scroll type with internal thermal overload protection and mounted on the compressor manufacturer's recommended rubber vibration isolators.
2. All units over 7 tons shall be multiple-stage and shall have a minimum of 2 stages of capacity control.
3. System shall be equipped with automatic re-set low pressure and manual reset high pressure refrigerant controls.
4. Unit shall be equipped with Schrader type service fittings on both the high side and low pressure sides of the system.
5. Unit shall be equipped with refrigerant liquid line driers.
6. Lead circuit(s) shall be provided with hot gas bypass.
7. See schedules for additional controls and requirements.

I. Gas Heating Section:

1. Unit shall be provided with a gas heating furnace consisting of an [aluminized steel] [stainless steel] heat exchanger with multiple concavities, and induced draft blower and

an electric pressure switch to lockout the gas valve until the combustion chamber is purged and combustion air flow is established.

2. Unit shall be provided with a gas ignition system consisting of an electronic ignitor to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
3. Unit's tubular gas heat exchanger will carry a 15 year non pro-rated warranty.
4. Unit shall heat using natural gas and be equipped with a modulating gas valve, adjustable speed combustion blower and tubular heat exchanger. The completely factory mounted gas heating assembly shall be capable of operating at any firing rate between 100% and 30% of rated capacity. The combustion air and gas firing rate shall both be capable of modulation. A discharge air sensor shall be provided for field installation in the supply air ductwork to sense the discharge air temperature. The discharge air setpoint shall be adjusted at the electronic controller within the rooftop unit control compartment. Heating control shall be capable of operation initiated by a call for heat from a thermostat.
5. See schedules for additional controls.

J. Power Option:

1. Unit shall be provided with a factory installed and wired internal disconnect switch with fusing.

K. Filters:

1. Unit to be furnished with 2" pleated throw-away 30% efficient supply air filters.

L. Temperature Control:

1. Unit shall be equipped with a discharge air temperature controller. Controller to be multi-compressor units. Controller to include compressor anti-short cycle protection for each compressor.
   a. Unit shall be equipped with hot gas by-pass control on lead refrigeration stage to protect against evaporator frosting at low air flows and suction pressures.
   b. Unit to be equipped with an electronic supply air discharge temperature controller. Controller to be multi-stage on multi-compressor units. Controller to include compressor anti-short cycle protection for each compressor.

M. Roof Curbs:

1. Roof curbs shall be constructed of galvanized steel.

2. Provide ¾" rubber waffle vibration isolation around full curb perimeter.

O
R

Provide full perimeter spring isolation rail.

O
R

Provide rubber gasket around full curb perimeter.

PART 3 - EXECUTION

3.1 EXAMINATION:

A. Examine areas and conditions under which rooftop units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION:

A. General: Install rooftop units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Support: Install and secure roof curb to roof structure, in accordance with National Roofing Contractors' Association (NRCA) installation recommendations and shop drawings. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing.

C. Electrical Connections: Refer to Section 26 05 83 "Electrical Connections for Equipment" for final connections to equipment and installation of loose-shipped electrical components.

3.3 DEMONSTRATION:

A. Start-Up Services:

1. Provide the services of a factory-authorized service representative to start-up rooftop units, in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

B. Operating and Maintenance Training:

1. Provide services of manufacturer's service representative to instruct Owner's personnel in operation and maintenance of rooftop units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and trouble-shooting procedures plus procedures for obtaining repair parts and technical assistance. Review operating and maintenance data contained in the Operating and Maintenance Manuals specified in the LPS General Conditions of the Contract and Divisions 20 through 25.

2. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

**END OF SECTION 23 74 00**

# SECTION 23 75 13 – AIR HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of air handling unit work is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Section 23 05 48 and other Divisions 20 through 25 sections for vibration control units used in conjunction with air handling units, field-applied insulation to air handling units, piping required in conjunction with air handling units; not work of this section.

C. Electrical Work: Refer to Section 23 05 13 "Motors, Starters and Drives" for requirements.

D. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels.
   a. Control wiring specified as work of Section 23 09 23 for Automatic Temperature Controls is work of that section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of semi-custom packaged air handling units with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.

2. ARI Compliance: Test and rate air handling units in accordance with ARI 260, 410, 430 and 1060D display certification symbol on units of certified models.

3. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".

4. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

5. UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA Standards.

6. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data for air handling units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly

indicated, motor electrical characteristics, gauges and finishes of materials, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing section by section unit dimensions, weight loadings, required clearances, construction details, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to air handling units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Deliver air handling units with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle air handling units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; replace and return damaged components to air handling unit manufacturer.

C. Store air handling units in clean dry place and protect from weather and construction traffic.

D. Comply with Manufacturer's rigging and installation instructions for unloading air handling units, and moving them to final location.

E. Air handling units shall be broken down and shipped in components as field conditions require. A factory-authorized representative shall inspect the final installation to certify that the unit has been reassembled per factory recommendations and specifications.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide air handling units of one of the following:

1. American Air Filter
2. Carrier
3. McQuay
4. Pace
5. Trane
6. York

2.2 OUTDOOR AIR HANDLING UNITS:

| Edit Note: The following is based on Trane T-Series outdoor unit. |
|---|

A. Air Handling Units: Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. If air handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to verify performance of fan(s). Any costs incurred to adjust fans to meet scheduled capacities shall be the sole responsibility of the contractor.

B. Air Coils: Certify capacities, pressure drops and selection procedures shall be in accordance with ARI 410-91.

C. Provide one set of disposable filters and one set of belts for each air handler.

D. A parts warranty for one year from date of start-up shall be provided at no additional cost.

E. Factory-fabricate air handling units of sizes, capacities and configurations as scheduled on drawings.

F. The unit shall be able to withstand up to 1.5 times design static pressure or 8-inch w.c., whichever is less, with no more than 0.005 inch deflection per inch of panel span.

G. The unit base design shall allow unit to rest on top of roof curb when field-installed. Entire length and width under base shall be sealed for weather tight seal.

1. Provide full perimeter gasket to isolate unit from curb.

H. Casing:

1. All panels shall be double-wall construction. Interior and exterior panels shall be constructed of galvanized steel. Panel insulation system shall provide a minimum R value of 12. Insulation shall conform to NFPA 90 requirements.

2. Panels shall be fully removable to allow for a proper way to thoroughly clean panels and to access internal parts. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.

3. Access doors shall be constructed with a double-wall of solid G90 galvanized steel interior panel. Gasketing around the full perimeter of the access door shall be used to prevent air and water leakage.

4. To facilitate inspection of internal components, provide sealed tempered glass view windows in doors accessing moving parts.

5. Perforated interior liner with fiberglass insulation shall be applied to [entire unit] [fan section only].

6. Provide marine lights in all sections. Preferred marine light shall be UL light wet location fluorescent light. Light shall be complete with bulb, ballast, and junction box.

7. External surface of unit casing shall be prepared and factory coated with a minimum 1.5 mil enamel finish or equal. Unit casing exterior with factory coating shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Unit casing will be provided with manufacturer's standard color.

8. Unit roof shall be sloped a minimum .25 inch per foot either from one side of unit to other or from center to sides of the unit. Roof assembly shall overhang all walls of units by 2 inch minimum.

9. For units with outside air requirements, manufacturer shall provide inlet hood with high performance moisture eliminator to prevent water carryover into unit casing room from outside air. Hoods shall be sized for 100% economizer cycle. If louvers are provided, then louvers shall be tested by an independent AMCA approved laboratory for water carryover and air pressure drop in accordance with AMCA standard 500, and testing reports shall be supplied with the submittal data.

10. Galvanized steel roof mounting curb with wood nailing strip, and neoprene gasket shall be supplied by the unit manufacturer. If unit requires external piping cabinet, a separate curb shall be supplied for support of the external cabinet.

I. Fans Sections

1. Provide supply fan section(s) with [FC] [BI] [AF] double width, double inlet centrifugal fan designed and suitable for class of service indicated in the unit schedule. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
   a. Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 400,000 hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit attached to drive side bearing support.

OR

1. Provide supply fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated width lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping.
   a. Equip centrifugal plug fans with self-aligning, grease lubricated pillow-block ball bearings selected for L-50 400,000 hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive side bearing support.

2. Mount fans on [inertia base] isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with 1 inch spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.

3. Fan sections shall have full height, double wall, hinged doors on drive side for inspection and maintenance of internal components.

4. Fan sections with plug fans shall have[door switches for fan shut-off] [galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened]. Design access door guards for removal from outside of unit. On plug fan sections with vertical down discharge a safety grate shall cover entire down discharge opening to prevent service personnel from falling into supply air ductwork.

5. Statically and dynamically balance fan section assemblies. Fan section assemblies include fan wheels, shafts, bearings, drives, belts, isolation bases and isolators. Allow isolators to free float when performing fan balance. Measure vibration at each fan shaft bearing in horizontal, vertical and axial directions. Balance at design RPM as scheduled on drawings.

6. For fan sections controlled by variable frequency drives, balance at speeds between 25% and 100% of design RPM.

J. Motors and Drives:

1. Factory-install all motors on slide base to permit adjustment of belt tension.

2. Fan motors shall be heavy duty, [high efficiency open drip-proof] [high efficiency TEFC] [premium efficiency open drip-proof] [premium efficiency TEFC], operable at 460 volts, 60 Hz, 3-phase.

3. V-belt drive shall be [variable] [fixed] pitch rated at 1.2 times the motor nameplate.

K. Coils Section:

1. The wet section of the unit, defined as the entering air side of the dehumidification coil to the leaving edge of the drain pan, shall be insulated. The insulated shall meet UL181 requirements. The air stream surface of the insulation shall be constructed or coated such that it is not biodegradable, repels water and it can be cleaned to prevent microbial growth. The manufacturer's maintenance instructions shall describe the proper cleaning procedure for the unit.

2. Construct coils of plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes my means of mechanical expansion of tubes. Do not use soldering or tinning in bonding process.

3. Construct coil casings of galvanized steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through airstream.

4. Coil Design:
   a. 10 fins per inch maximum
   b. 500 FPM maximum velocity for cooling coils
   c. 700 FPM maximum velocity for heating coils
   d. 6 row minimum cooling coil
   e. Minimum 3 FPS water velocity for chilled water coils.
   f. Minimum 1.5 FPS water velocity for constantly pumped chilled water coils.
   g. Minimum 1.5 FPS water velocity for hot water coils.
   h. Minimum 0.75 FPS water velocity for constantly pumped hot water coils.

5. Hydronic Coils:
   a. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.
   b. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
   c. Construct headers of round copper pipe or cast iron.
   d. Construct tubes of ½ inch OD minimum .016 inch thick copper and construct fins of aluminum.

6. Steam Heating Coils:
   a. Clearly label supply and return connections on outside of units.
   b. Provide non-freeze steam distributing type coils. Pitch steam coils in units for proper drainage of steam condensate from coils.
   c. Proof test coils to 300 psig air under water and leak test coils to 200 psig air pressure under water.
   d. Construct headers of cast iron or round copper pipe.

e. Construct tubes of 5/8 inch OD copper inner tubes and 1 inch OD minimum .031 inch thick copper outer tubes. Construct fins of aluminum.
f. Inner tubes shall have orifices that ensure even steam distribution across coil face. Direct orifices toward return connections to ensure steam condensate is discharged from coils.

7. Refrigerant Cooling Coils:
   a. Clearly label suction and liquid connections on outside of units.
   b. Proof test coils to 450 psig air under water and leak test coils to 300 psig air pressure under water. Dry insides of coils after testing and seal all connections.
   c. Construct suction headers of copper tubing. Suction connections shall penetrate unit casings to allow for sweat connections to refrigerant lines.
   d. Coils shall have equalizing type vertical distributors sized in conjunction with capacities of coils.

L. Drain Pan Construction:

1. Provide insulated drain pans constructed of G90-U galvanized steel exterior panels and G90-U galvanized steel interior liner. Encase insulation between exterior and interior walls. Drain pans shall be sloped in 2 planes; cross break interior pans and pitch toward drain connections to ensure complete condensate drainage. Units with cooling coils shall have drain pans under complete cooling coil section. All drain pan connections will be to the side of the unit to enable proper trapping. Units without 2-way sloped drain pans shall coat drain pans with anti-microbial treatment.

M. External Piping Enclosure:

1. Piping enclosure shall be supplied by the manufacturer factory assembled and shall be of the same construction as the main unit casing. Piping cabinet shall be external to the unit and be shipped separate for field installation in order to facilitate piping of the unit coil(s). Piping cabinet to cover unit sections as specified on schedule and shall have access door(s), or removable panels, as specified.

N. Filters:

1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter sections shall have filter guides and full height, double-wall, hinged doors for filter removal. Filter sections shall flange to other unit components. Provide filter block-offs as required to prevent air bypass around filters.

2. Provide 2 inch Merv 8 flat filter sections with throwaway filters. Filters shall be removable from one side(s) of filter sections.

3. Provide high efficiency final filter sections with 12” cartridge filters and 2” throwaway media 30% pre-filters in order to provide proper filtration. High efficiency filters shall be Merv 14 and rated in accordance with ASHRAE 52 and UL class 1 or class 2. Filters shall be removable from one side of filter sections.

O. Dampers:

1. Provide internally mounted ultra-low leak outside air dampers. Dampers shall be Ruskin CD60 double skin airfoil design or equivalent. Construct damper blades and damper frames of galvanized steel. Provide parallel blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 5 CFM/square foot at one inch water gage and 9

CFM/square foot at 4 inches water gage. All leakage testing and pressure ratings based on AMCA Publication 500.

OR

Provide dampers to modulate the volume of return air. Damper blades shall be galvanized steel, housed in an axle rod rotating on bearings. Blade seals are required to assure tight closure. All dampers shall be rated for a maximum leakage rate of less than 1 percent of nominal CFM at one-inch w.g.

2. Provide a factory-mounted damper/airflow monitoring station in the outdoor air damper opening of the mixing box. Damper blades shall be galvanized steel, housed in a galvanized steel frame and mechanically fastened to an axle rod rotating on bearings. The dampers shall be rated for a maximum leakage rate of less than 1 percent of nominal CFM (L/s) at 1 in. wg (249 PA). The airflow measurement station shall measure up to 100% of airflow. The airflow monitoring station shall output a 2-10 VDC signal representing velocity and shall have a total accuracy of (+/-) 5 percent of actual flow down to 15 percent of nominal flow between -40° F (-40.0 ° C) and +158 ° F (70.0 ° C). Airflow monitoring stations that require a change in duct arrangements from the current design will not be acceptable.

OR

Provide solid state electronic air measurement system (EAMS) as specified on schedule and drawings. Contractor is responsible for mounting EAMS in strict accordance with manufacturer's recommendations. EAMS station shall be capable of functioning accurately between -20 degrees F and +158 degrees F and have the ability to transmit a 2-10 VDC linear signal representative of velocity. The measurement system shall be factory calibrated with a total accuracy of +/- 5% of actual flow down to 15% of the nominal flow. Total EAMS accuracy shall include and depend upon: temperature, compensation, humidity, repeatability, turbulence and placement. If required, field assembly and field calibration of the airflow measurement stations shall be the responsibility of the installing contractor.

3. Provide low leak face any bypass dampers as scheduled on drawings. Dampers shall be Ruskin CD60 double skin airfoil design or equivalent. Construct damper blades and damper frames of galvanized steel. Provide opposed blade action with metal compressible jamb seals and extruded vinyl blade edge seals. Blades shall rotate on stainless steel sleeve bearings. Mechanically link face dampers to bypass dampers, and provide end driven control shafts. Damper blade lengths shall not exceed 60 inches. Leakage rate shall not exceed 5 CFM/square foot at one inch water gage and 9 CFM/square foot at 4 inch water guage.

P. Access Sections:

1. Access for inspection and cleaning of the unit drain pan, coils and fan section shall be provided. The unit shall be installed for proper access. Procedures for proper access, inspection and cleaning of the unit shall be included in the maintenance manual. Access sections shall have double wall, hinged doors on one side of sections.
   a. To facilitate inspection of internal components, provide sealed glass view windows on access doors accessing moving parts.
   b. Provide marine lights inside access sections. Construct marine lights of sealed glass fixtures with wire guards to deep electrical sockets dry and protect fixtures from damage.

Q. General Sections:

1. Air Blender: The blender shall be of the rotary design with radial blades. Blender section shall have the proper distances upstream and downstream to provide a minimum mixing

effectiveness of 75 percent when mixing 50 percent outside air and 50 percent return air at 50 $^{o}$ F initial inlet temperature differential. Casing shall be constructed per Article 2.4 Paragraph A-H. Insulation shall be per Article 2.4, Paragraph A. Access doors shall be provided on [ACCESS DOORS PLACEMENT] sides of section [doors shall be constructed per Article 2.4 paragraph C].

2. Moisture Eliminator: Provide moisture eliminator with galvanized sine wave fins and drain pans in the casing.

3. Diffuser: Provide a diffuser section as shown on the drawings to promote equal air distribution across coils and filters.

R. Integral Face and Bypass Coil:

1. Heating coil shall be hot water and shall be provided as shown on the drawings and schedule. Each heating coil is to consist of built-in series of finned heating elements and bypasses with interlocking dampers. Each coil shall be capable of maintaining a constant discharge air temperature regardless of variations in entering air temperature with full steam pressure or full hot water flow on the coil at all times.

2. Proportioning of the air shall be that the temperature at any point in a plane parallel to the leaving side will not vary more than 5 degrees F from the average discharge temperature. The IFB coil section shall have the required space between the leaving side and the entering side of any downstream coils for this application as recommended by the coil manufacturer.

3. Dampers shall be 16 gauge roll formed, cold rolled galvanized steel. Finned heating elements shall be fabricated of seamless return bend type copper tubes with rectangular aluminum fins spaced not closer than 12 fins per inch. Finned elements shall be factory tested at 200 psi steam and 1000 lbs. hydrostatic pressure.

S. Roof Curb: Provide a roof curb designed to support the unit on the roof. The curb shall compensate for any structural roof slope and shall accommodate any sloped insulation. The curb shall be a minimum of 12 inches above the finished roof at any point.

2.3 INDOOR AIR HANDLING UNITS:

EDIT NOTE: THE FOLLOWING IS BASED ON TRANE MCC INDOOR UNIT.

A. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with current ARI 410 standard.

B. Certify air-handling units in accordance with ARI 430 standard.

C. Provide one set of extra filters and one set of belts for each air handler.

D. The equipment manufacturer shall provide, at no additional cost, a standard parts warranty the covers a period of one year from unit start-up. This warrants that all products are free from defects in material and workmanship and shall meet the capacities and ratings set forth in the equipment manufacturer's catalog and bulletins.

E. Unit Casing:

1. Unit shall be constructed of a complete structural frame with removable panels. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of galvanized steel. Casing finished tomeet ASTMB 117 250-hour salt-spray test. The removal of side panels shall not affect the structural integrity of the unit. All removable panels shall

be gasketed to minimize air leakage. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

2. Access panel and/or access doors shall be available on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection and maintenance. If panels are not removable, manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.

3. Access doors shall be double wall construction to prevent damage to insulation during routine maintenance.

4. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of all interior surfaces.

5. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.

6. All joints between exterior panels and structural frames, as well as joints between module frames, shall be properly sealed and gasketed to provide an air seal.

7. Insulation – high density, matte-faced-interior surface of unit casing shall be acoustically and thermally lined. Insulation shall be installed with adhesive. Insulation shall have a minimum R-value of 4 and shall be UL listed. The installation shall comply with NFPA 90A and B requirements. If edges of fiberglass insulation are exposed, the manufacturer shall be responsible for sealing exposed edges with mastic sealer to prevent erosion into the air-stream.

8. To facilitate inspection if internal components, provide sealed tempered glass view windows in doors accessing moving parts.

9. Provide marine lights in all sections. Marine light shall be UL listed for wet locations. Light shall be complete with bulb and junction box.

10. Provide concrete 4" housekeeping pad under casing. Isolate unit form pad with [rubber gasket] [3/4" rubber waffle pad] [full perimeter spring rail].

F. Fans:

1. Provide [DWDI FC] [DWDI BI] [DWDI BIAF] [plug type] supply fans. Provide [DWDI FC] [DWDI BI] [DWDI BIAF] [plug type] return fans. Fan shafts shall be solid, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment as speeds between 25% and 100% of design RPM. If fans are not factory-tested responsible for cost and labor associated with field balancing and certified vibration performance. Fan wheels shall be keyed to fan shafts to prevent slipping.

2. When plug fans are used, provide door switches for fan shut-down when access door is opened.

3. Provide grease lubricated ball bearings selected for L-50 400,000 hour average life per ANSI/AFBMA 9. Greasable bearings shall have lubrication lines extended to the drive

side of the unit. Lubrication lines shall be a clear, high-pressure, polymer to aid in visual inspection. Extend both grease lubrication lines to drive side of unit and rigidly attach to drive side bearing support with zerk fittings. If extended lubrication lines are not provided, manufacturer shall provide permanently lubricated bearing with engineering calculations for proof of bearing life.

4. Fans shall be mounted on [inertia base] isolation bases. Internally mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Flexible canvas ducts shall be installed between fan and unit casing to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A and UL 181 requirements.

5. Fan modules shall have a minimum of one access door located on the drive side of the unit to allow inspection and maintenance of the fan, motor, and drive components.

6. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect workers from accidental contact with the belts and sheaves.

7. Motors and Drives:
   a. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change.
   b. V-belt drives shall be [constant] [fixed] pitch rated at 1.2 times the motor nameplate.

G. Coils:

1. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain-pan under the coil.

2. Coils shall be manufactured with plate fins to minimize water carryover and maximized airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across coils as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.

3. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.

4. All coils shall be completely cleaned prior to installation into the air handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated in order to minimize the chance for water carryover.

5. On stacked cooling coils, intermediate drain pans shall be installed between the coils. Intermediate drain pans shall have drop tubes to guide condensate to the main drain pan, thus preventing flooding of lower coils that would result in moisture carryover.

6. Hydronic Coils:
   a. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit air-flow.

b. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
c. Headers shall be constructed of round copper pipe or cast iron.
d. Tubes shall be ½ inch O.D. minimum 0.016 inch thick copper. Fins shall be aluminum.
e. 10 fins per inch maximum.
f. 500 FPM maximum velocity for hydronic coils
g. 700 FPM maximum velocity for heating coils.
h. Minimum 6 row cooling coil
i. Minimum 3 FPS water velocity for chilled water coils.
j. Minimum 1.5 FPS water velocity for constantly pumped chilled water coils.
k. Minimum 1.5 FPS water velocity for hot water coils
l. Minimum 0.75 FPS water velocity for constantly pumped hot water coils.

7. Steam Heating Coils:
   a. Steam supply, condensate return and vacuum breaker connections shall be clearly labeled on outside of units.
   b. Coils shall be non-freeze steam distributing type. Coils shall be pitched in units for proper drainage of steam condensate from coils.
   c. Coils shall be proof tested to 300 psig and leak tested to 200 psig air pressure under water.
   d. Headers shall be constructed of round copper pipe or cast iron.
   e. Tubes shall consist of 5/8 inch O.D. minimum 0.035 inch thick copper inner tubes and 1 inch O.D. minimum 0.031 inch thick copper outer tubes. Fins shall be aluminum.
   f. Inner tubes shall have orifices that ensure even steam distribution throughout the length of the outer tube. Orifices shall direct steam toward return connections to ensure steam condensate is properly drained from coils to prevent flashing of condensate.

8. Refrigerant Cooling Coils:
   a. Refrigerant suction and liquid connections shall be clearly labeled on outside of units.
   b. Coils shall be proof tested to 450 psig and leak tested to 30 psig air pressure under water. After testing, insides of tubes shall be air dried, charged with dry nitrogen, and sealed to prevent contamination.
   c. Refrigerant suction and liquid headers shall be constructed of copper tubing. Suction and liquid connections shall penetrate unit casings to allow for sweat connections to refrigerant lines.
   d. Tubes shall be ½ inch O.D. minimum .016 inch thick copper. Fins shall be aluminum.
   e. Coils shall have equalizing type vertical distributors sized in conjunction with capacities of coils.

9. Integral Face and Bypass Coils (IFB)
   a. Heating coil shall be hot water and shall be provided as shown on the drawings and schedule. Each heating coil is to consist of built-in series of finned heating elements and bypasses with interlocked dampers. Each coil shall be designed to maintain a constant discharge air temperature regardless of variations in entering air temperature with full steam pressure or full hot water flow on coil at all times.
   b. Coil shall be designed to maintain no more than a 5 degree F variance from the average discharge air temperature to minimize air stratification. The air handler shall have sufficient space downstream of the IFB coil as recommended by the IFB coil manufacturer to minimize stratification.
   c. Dampers shall be galvanized steel. All bearings, seals, damper blades and linkage operation shall not be impaired by the high temperature associated with

operation of the IFB coil. Finned elements shall be factory tested at 200 psi steam and 1000 lbs. hydrostatic pressure.

H. Base-Level Drain Pans:

1. Insulation shall be encased between exterior and interior walls. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section. Cooling coil drain pans shall be sloped in 2 planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's requirements. See section 2.05, paragraph E, for specifications on intermediate drain pans between cooling coils.

2. Units with heating coils shall have a drain pan under complete heating coil section sloped in 2 planes and pitched toward drain connections to ensure proper drainage during cleaning and to capture water in the event of a coil failure.

3. All drain pan connections supplied by unit manufacturer including, piping and piping connections extending from stainless steel drain pans shall be constructed of stainless steel. The contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

4. Flat drain pans shall be acceptable in sections that may have incidental, but not continuous contact with moisture. Flat drain-pans shall be accessible for cleaning.

I. Filters:

1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter sections shall have filter guides and full height, double-wall, hinged doors for filter removal. Filter sections shall flange to other unit components. Provide filter block-offs as required to prevent air bypass around filters.

2. Provide 2 inch Merv 8 flat filter sections with throwaway filters. Filters shall be removable from one side(s) of filter sections.

3. Provide high efficiency filter sections with 12" cartridge filters. High efficiency filters shall be Merv 14 efficient and rated in accordance with ASHRAE 52 and UL class 1 or class 2. Filters shall be removable from one side of filter sections.

4. Provide HEPA final filter section with maximum face velocity of 500 fpm. HEPA filter section shall have negligible bypass. HEPA filters shall be 99.97% efficient when tested with 0.3 micron thermally generated particulates. Filters shall be housed in rear-loading type filter rack.

J. Dampers:

1. All dampers, with the exception of external bypass and multi-zones (if scheduled), shall be internally mounted. Dampers shall be premium ultra-low leak and located as scheduled. Dampers shall be Ruskin CD60 double-skin airfoil design or equivalent for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one inch water gauge and 9 CFM/square foot at 4 inch water gauge. All leakage testing and pressure ratings shall be based on AMCA publication 500. Manufacturer shall submit brand and model of damper(s) being furnished.

K. Access Sections:

1. Access for inspection and cleaning of the unit drain pan, coils and fans sections shall be provided. The unit shall be installed for proper access. Procedure for proper access, inspection and cleaning of the unit shall be included in the maintenance manual. Access section shall have double wall, hinged, removable access doors on one side of section. Construct doors per section 2.03 paragraphs D, E and F.

2. To facilitate inspection of internal components, provide sealed tempered glass view windows in access doors accessing moving parts.

3. Provide marine lights in sections as specified on schedule. Marine light shall be UL-listed for wet locations. Light shall be complete with bulb and junction box.

L. General Unit Sections:

1. Air Blender: The blender shall be of the rotary design with radial blades. Blender shall have the proper distances upstream and downstream s recommended by the blender manufacturer. Minimum mixing effectiveness shall be 75 percent when mixing 50 percent outside air and 50 percent return air at 50 F initial inlet temperature differential. Construct blender of 0.080" aluminum.

2. Moisture Eliminator: Provide moisture eliminator with galvanized fins and drain pan in the casing.

3. Internal Face and Bypass Section: Provide an internal face and bypass section as shown on the drawings. Construct dampers per units provided with coil immediately downstream of bypassed coil shall be provided with space equivalent to bypassed coil height or greater to insure full face activation of downstream coil.

4. External Face and Bypass Section: Provide an external face and bypass section as shown on the drawings. Contractor shall be responsible for construction of bypass duct, including fabrication, installation and fabrication of return opening into unit. Manufacturer shall provide calculations for determining required opening to return bypass air back into unit.

5. Diffuser Section: On units provided with coils or filters immediately downstream of double inlet housed centrifugal fans, provide a factory mounted diffuser section as shown on the drawings to promote equal air distribution.

6. Acoustical Attenuator: Provide factory mounted sound attenuation section(s). Attenuation section(s) shall be made of double wall construction with minimum 20 gauge galvanized perforated steel liner. Acoustical attenuator(s) length shall be sized to meet discharge sound power levels as defined in schedule. Space shall be provided both upstream and downstream of attenuator section(s) as required by attenuator manufacturer to insure smooth transition of airflow into and out of attenuator.

7. Energy Wheel Section:
   a. The air handling unit shall have a total energy wheel sized per the ventilation requirement as defined on the schedule. The energy wheel shall be an integral part of the air handling unit. Unit shall be installed as a complete system with assembled and ducted energy recovery device. Manufacturer shall include performance information in the submittal that meets or exceeds scheduled wheel performance.
   b. Energy wheel shall be sized to handle minimum OA ventilation requirement as defined on schedule. Energy wheel shall be capable of 100% economizing. Wheel section shall include variable effectiveness damper. On mixed air units, the return damper shall be an integral part of the energy wheel section and shall be sized for adequate mixed air control.

c. The air handling unit shall be certified by ARI to contain a rotary energy recovery wheel that is ARI 1060 certified. The air handling unit nameplate shall bear the ARI 1060 certification nameplate shall bear the ARI 1060 certification label. Performance characteristics of the energy wheel shall be provided as defined by ARI 1060. The energy wheel shall be an enthalpy wheel capable of sensible and latent heat transfer. Sensible, latent and total net effectiveness of the wheel performance shall meet or exceed performance as defined on schedule. The calculated total net effectiveness of the recovery device shall not be less than 70 percent when the specified ventilation flow rate equals the exhaust flow rate. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recover cassette shall be an Underwriters Laboratories (UL)-recognized component certified for mechanical, electrical and fire safety in accordance with UL standard 1812.

d. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor, and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be self-adjustable. Seals shall be factory set. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

e. The wheel drive motor shall be provided, mounted in the cassette frame and supplied with a connector for field service. The wheel drive motor shall be thermally protected and UL component recognized. On units that require drive belt tensioners for the wheel belt/motor assembly, the wheel manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. The wheel drive motor shall be no greater than 0.33 hp and shall be the same voltage as the air handler fan motors.

f. Energy recovery media for wheels larger than 25 inches in diameter shall be provided in the form of removable segments. The segments shall be removable without the use of tools to facilitate maintenance and cleaning as required. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The desiccant shall not dissolve in the presence of water or high humidity.

g. Access doors shall be provided on all air entering and air leaving sides of wheel to allow for wheel maintenance, belt or motor removal.

8. Air to Air Heat Exchanger Section

a. The heat exchanger shall be a cross flow, aluminum plate type exchanger. The aluminum plates shall be die-formed from 99.9% pure aluminum with a plate profile that maximizes efficiency and cleanability and minimizes pressure loss. The connection plate edges shall be double-folded and sealed internally with a synthetic resin. The plate core shall be assembled into a strong, self-supporting frame made of aluminum corner extrusions and galvanized steel end plates. Access to all four sides of the exchanger for cleaning and inspection shall be provided.

b. Air handling unit shall be configured to allow for inspection and cleaning of all four air paths of plate heat exchanger.

c. The heat exchanger shall meet the performance as shown on the schedule. No frost control or bypass dampers are required.

9. Humidifier Section:

a. Manufacturer shall provide factory packaged steam injection type humidifier. Humidifier shall include a fabricated separator/header and multiple dispersion

tube with all wetted parts constructed of stainless steel. Separator/header shall include a pipe-within-a-pipe design to insure proper separation and drainage of condensate for units supplying 5,000 CFM or more. Below 5,000 CRM, separator/header shall have a single pipe design. All active tube-to-header joints are welded. No O-rings or slip couplings are acceptable. Active tubes are unjacketed so no air stream heat gain takes place when the humidifier is not in use. Active tubes are internally fitted with a series of stainless steel tubelets which extend into the center of the tube. Tubelets are sized and spaced to accept steam from the separator/header and provide a dry and uniform discharge of steam. Unit manufacturer shall provide sufficient absorption space upstream/downstream of humidifier as recommended by humidifier manufacturer.

b. The humidifier shall include steam specialties required to meet scheduled performance. Steam specialties shall include a steam control valve, inverted bucket trap and steam supply strainer that will ship with unit for installation by piping contractor. All pipe connections shall be made from one side of the casing section.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which air handling units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF AIR HANDLING UNITS:

A. General: Install air handling units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.

B. Coordination: Coordinate with other work, including ductwork, floor construction, roof decking, and piping, as necessary to interface installation of air handling units with other work.

C. Access: Provide access space around air handling units for service as indicated, but in no case less than that recommended by manufacturer.

D. Support: Install floor-mounted air handling units on 4" high reinforced concrete pad, a minimum of 4" larger on each side than unit base.

E. Support: Install roof-mounted air handling units on roof curb. Anchor unit to curb with removable fasteners.

F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

G. Piping Connections: Refer to Divisions 20 through 23 sections. Provide piping, valves, accessories, gauges, supports, and as indicated.

1. Provide flexible connectors shutoff valves, balancing valves, unions, thermometers (supply and return), P & T types (supply & return) and other accessories on all piping connections.

H. Duct Connections: Refer to Division 23 Air Distribution sections. Provide ductwork, accessories, etc., as indicated.

I. Grounding: Provide positive equipment ground for air handling unit components.

3.3 FIELD QUALITY CONTROL:

A. Testing: Upon completion of installation of air handling units, start-up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.

3.4 EXTRA STOCK:

A. Provide one complete extra set of filters for each air handling unit. Install new filters at completion of air handling system work, and prior to testing, adjusting, and balancing work. Obtain receipt from Owner that new filters have been installed.

B. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.

3.5 TRAINING:

A. Schedule a minimum of 4 hours of training with Owner. The manufacturer's representative and the installing contractor shall be present. The training shall be coordinated by the installing contractor, General Contractor, Architect/Engineer and the Owner in conjunction with the other mechanical equipment on the project.

B. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures. Review with the Owner's personnel, the contents of the Operating and Maintenance Data specified in the LPS General Conditions of the Contract and Divisions 20 through 25.

2. Schedule training with Owner through the Architect/Engineer with at least 7 days' prior notice.

**END OF SECTION 23 75 13**

# SECTION 23 81 23 - COMPUTER ROOM AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Provide computer room air conditioning units required as indicated by requirements of this section.

B. Types of computer room air conditioning units specified in this section include the following:

1. Chilled water computer room units.

2. Air Cooled computer room units.

3. Water Cooled computer room units.

4. Glycol Cooled computer room units.

C. Electrical Work: Refer to Section 23 05 13 "Motors, Starters and Drives" for requirements.

OR

Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 26:

1. Low voltage control wiring between computer room units and remote-mounted thermostats and controls.

2. Provide factory-mounted and factory-wired controls and electrical devices as specified in this section.

D. Provide factory-mounted and wired controls and electrical devices as specified in this section.

E. Refer to Division 26 sections for other electrical work including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.2 REFRIGERANTS:

A. All refrigerants used for each condensing unit shall be on the latest EPA list of approved refrigerants and environmentally friendly.

B. No CFC-based refrigerants shall be used.

1.3 QUALITY ASSURANCE:

A. Manufacturers' Qualifications: Firms regularly engaged in manufacture of computer room air conditioning units, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Provide capacity ratings for computer room air conditioning units in accordance with ARI Standard 360 "Standard for Commercial and Industrial Unitary Air-Conditioning Equipment".

2. ASHRAE Compliance: Construct refrigerating system of computer room air conditioning units in accordance with ASHRAE Standard 15 "Safety Code for Mechanical Refrigeration".

3. UL Compliance: Provide computer room air conditioning units which are UL-listed and - labeled.

4. NEC Compliance: Install computer room air conditioning units in accordance with National Electrical Code.

## 1.4 SUBMITTALS:

A. Each manufacturer shall describe in writing, how their company is addressing the CFC legislation issue. Provide equipment capable of accepting a substitute refrigerant. The equipment provided shall provide the scheduled capacity when the substitute refrigerant proposed, the nominal equipment capacity reduction effects (if any), performance in KW/Ton, the refrigerant change-out procedure and long-term maintenance effects the new refrigerant has on the equipment.

B. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights, furnished specialties and accessories; and installation and start-up instructions.

C. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to computer room air conditioning units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of computer room air conditioning units and controls. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

E. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

F. Maintenance Data: Submit maintenance data and parts list for each computer room air conditioning unit, control, and accessory; including "trouble-shooting" maintenance guide. Include this data and product data in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

## 1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handle computer room air conditioning units and components carefully to prevent damage, breaking, denting and scoring.

B. Store computer room air conditioning units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and installation instructions for unloading computer room air conditioning units, and moving units to final location for installation.

## 1.6 SPECIAL PROJECT WARRANTY:

A. Warranty on Motor/Compressor: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, motors/compressors with inadequate and defective

materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement is limited to component replacement only, and does not include labor for removal and reinstallation.

1. Warranty Period: 5 years from Date of Final Completion and Acceptance by Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Indoor Packaged Units:
   a. Liebert
   b. Airflow Co.
   c. Data Air, Inc.

2.2 COMPUTER ROOM AIR CONDITIONING UNITS (3 TONS TO 5 TONS):

A. General: Provide factory-assembled and tested chilled water/water cooled/glycol cooled/air cooled packaged units as specified /scheduled, consisting of casing, condensate pump, liquid tect sensor, [chilled water] [D.X.] [Glycol] [A frame type cooling coil], [air cooled condenser with fan speed control] [Lee-Tempwinter control system], water cooled condenser, glycol cooled condenser with pump package, dry cooler, fan, compressors, filters, electric reheat coil, [steam grid] [infrared with autoflush system] humidifier, floor stand, firestat, smoke detector disconnect switch(es) HOA Switches and controls. Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating, and exterior finish. Provide removable panels with 1-inch 1-1/2 lbs density fiber insulation and concealed fasteners for service and access to internal parts. Unit shall be downflow/upflow arrangement with return air in top/bottom front and supply air out bottom/top of unit. Provide knockouts for electrical and piping connections with the following options.

1. Provide [twenty-four (24)] [ ( ) ] inch high adjustable floor stands.

2. Provide top discharge air plenum with two (2) [three (3)] grilles.

3. Cabinet color shall be [Z-0180, light grey], [ ] without/with [ ] accent color.

4. Provide piping access through top of unit and discharge air plenum/bottom of unit.

C. Chilled Water Cooling Coil: Construct of copper tubes with aluminum fins. Pressure and leak tested at 1.5 times working pressure, the coil shall be of A-frame design, 4 rows with a minimum face area of 6.94 square feet. The unit coil capacity shall be controlled by a 250/400 psig rated, modulating valve. Provide factory piped coil with ball valve, bleed valve, flow switch, piping and 3-way modulating chilled water valve. Piping shall be arranged to allow unit to be piped from through the top/bottom of the unit casing discharge air plenum section. Provide stainless steel condensate drain pan. All factory provided piping, valves and fittings shall be insulated with minimum of 1" thick, 25/50 rated, fiberglass pipe insulation as specified in Section 23 07 00.

OR

DX Cooling Coil: Constructed of copper tubes and aluminum fins. Pressure and leak tested at 1.5 times working pressure, the coil shall be of A-frame design, 3 / 4 rows with

minimum face area of 6.94 square feet. The unit coil capacity shall be controlled by expansion valve.

D. Pre-piped coil shall be arranged to allow unit to be piped from through the top/bottom of the unit casing and discharge air plenum section. Provide stainless steel condensate drain pan.

E. Water Cooled Condenser: The water cooled condensers shall be coaxial counterflow type. Condenser shall be A.S.M.E. stamped for a maximum refrigerant pressure of 400 PSI at 300 degrees F. The unit shall require the GPM of the temperature water and have a maximum drop as scheduled on the drawings. The condenser circuit shall be pre-piped with a 2-way, 300/150 psig regulating valve which is head pressure activated.

F. Glycol Cooled Condenser: The system shall include a copper tube, aluminum fin coil, three-way solenoid valve and refrigerant check valve. The capacity of the coil shall be [ ] BTU/HR. The water regulating valves shall be pre-piped with head pressure activated 3-way/2-way with bypass regulating valve, with maximum water pressure of 150/300 PSI. The glycol cooled condensers shall be coaxial counterflow type. The condenser shall be A.S.M.E. stamped for a maximum pressure of 400 PSI at 300 degrees F. Condenser circuit shall be pre-piped with head pressure activated regulating valve and parallel bypass valve. The unit shall require the GPM and maximum pressure drop as scheduled on the drawings. The dry cooler shall be the low profile, slow speed, multiple, direct drive propeller fan type with fan speed control. The dry cooler shall be constructed of aluminum and contain copper tube aluminum fin coil with an integral electric control panel and disconnect switch. The dry cooler shall be designed for [ ] degrees F ambient. This system shall be provided with a single centrifugal pump mounted in a weather proof and vented enclosure. The pump shall be rated for the GPM and feet of head scheduled on the drawings.

OR

Air Cooled Condenser: The air cooled condenser shall be the low profile, direct drive propeller fan type. The condenser shall have refrigeration circuit rated at [ ] degrees F ambient. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil arranged for vertical air discharge. The winter control system for the air cooled condenser shall be Fan Speed Control and operate at -20 degrees F ambient. Variable speed motor shall be designed with ball bearings, permanent lubricated, internal overload protection, 40 degrees C rise at full speed, 65 degrees C rise at 10 RPM. The control system shall be complete with transducers, thermostats and electrical control circuit, factory pre-packaged in the integral condenser control box. The package shall include factory insulated receivers, pressure relief valves, head pressure three-way control valves and roto-lock valves.

Receivers shall be factory mounted ready for field connection to the air cooled condenser. The heater shall require separate power supply. Provide a factory mounted and wired disconnect switch for condenser control panel accessible from the exterior.

G. Compressor: The compressors shall be Hermetic type located in a separate compartment with crankcase heater, vibration isolators, thermal overloads, oil sight glass, manual reset high and low pressure switches and maximum operating speed of 1750 RPM. Refrigeration circuit shall include refrigerant sight glass with moisture indicator, adjustable externally equalized expansion valve and discharge service valve.

H. Fans: Provide variable speed, direct drive, double-inlet, forward curved, centrifugal fans with slide base. Provide 100,000 hours self-aligning, lubricated fan and motor bearings, and thermal overloads in motor.

I. Filters: Provide 2" thick fiberglass, throwaway pre-filters with 20% efficiency rating (ASHRAE 52-76).

J. Humidifier: Provide units with Armstrong steam grid, steam separator type with internal drying chamber and steam jacketed stainless steel distribution manifold. Complete system shall include pre-piped solenoid control valve, F & T steam trap, cleanable Y-strainer and fiberglass insulation. Humidifier shall have a capacity of [ ] lbs per hour at [ ] psig steam supply pressure. Infrared type with high intensity quartz lamps, serviceable stainless steel evaporator pan, prepiped for final connector and automatic water supply system with adjustable water- overfeed. The humidifier shall have a capacity of [ ] lbs/hr using a [ ] kw electric element. Provide autoflush system.

K. Electric Heating Coil: Provide 2 stage 9/15 Kw electric heating coil with built-in auto-reset thermal overload protection wired into the control circuit and manual-reset thermal overload protection wired into the power circuit. Controlling contactors shall be mercury relay type and shall be wired so as to de-energize the heater circuits. All contactors and over current protection devices shall be factory wired and installed in accordance with the National Electric Code, National Fire Protection Association and Underwriters' Laboratories.

L. Condensate Pump: The condensate pump shall have a capacity of 145 GPH at 20 foot head complete with integral float switch, pump, motor assembly and reservoir.

M. Liquid-Tect Sensor: Provide [ ] solid state water sensor(s) under the unit/raised floor.

N. Floor Stand: The floor stand shall be constructed of a heliarc welded tubular steel frame, shall have adjustable legs with vibration isolation pads and floor stand shall be [ ] inches high.

O. Disconnect Switch(es): The non-locking/locking type non-automatic molded case circuit breaker shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the accent panel closed and prevent access to the high voltage electrical components until switched to the "OFF" position. Electrical panel shall be in accordance with UL requirements, pre-wired and tested. Comply with N.E.C. and local codes.

P. Firestat: The firestat shall shut down the environmental control system when activated and shall be mounted in the electrical panel with sensing element in the return air compartment.

Q. Control Processor (Level 0): The control system shall be microprocessor based. The system shall be provided with two 0.43 inch high, seven segment LED numerical display to allow observation of room temperature and humidity and each setable function:

1. Temperature Setpoint 65-85$^{o}$F.

2. Temperature Sensitivity +1$^{o}$ +5$^{o}$F.

3. Humidity Setpoint 40-60% R.H.

4. Humidity Sensitivity +1% + 10%.

5. Humidifier Flush Rate.

6. Normal Operating Modes (Heating, Cooling, Humidification/ Dehumidification) shall be indicated by colored LEDs on the unit mounted display panel.

7. The control system shall monitor unit operation and activate an audible and visual alarm in the event of the following factory preset alarm conditions:

a. High Temperature
b. Low Temperature
c. High Humidity
d. Low Humidity
e. Change Filters
f. Loss of air
g. Local Alarm (Customer Accessible)

8. A common alarm light shall be activated when any of the above conditions exist and indicate high head pressure and water under floor.

9. Panel shall have start-stop push buttons.

10. Provide Sitemaster having the capacity to monitor the operation of up to 24 environmental control or power conditioning systems. The 9" CRT display shall be provided in English. The Sitemaster shall have the capability to access and change (at the user direction) the temperature and humidity setpoints and sensitivities of each unit. The printer shall provide chronological alarm information and shall also be capable of being programmed to print out environmental conditions or operating modes at each unit.

R. Testing and Certification: All equipment shall be factory run and tested with certified test data furnished.

2.3 COMPUTER ROOM AIR CONDITIONING UNITS (ABOVE 5 TONS):

A. General: Provide factory-assembled and tested packaged units as specified, consisting of casing:

1. condensate pump
2. liquid tect sensor
3. chilled water
4. [D.X.] [Glycol] cooling coil
5. air cooled condenser with fan speed control
6. Lee-Tempwinter control system
7. water cooled condenser
8. glycol cooled condenser with pump package
9. dry cooler
10. fans
11. compressors
12. filters
13. [electric] [steam] [hot water] [hot gas] reheat coil
14. [steam grid] [infrared] humidifier
15. floor stand
16. firestat
17. smoke detector
18. disconnect switch(es)
19. four step system
20. and controls.

Provide capacities and electrical characteristics as scheduled.

B. Casing: Provide manufacturer's standard casing construction, corrosion protection coating and exterior finish. Provide removable panels with 1" 1-1/2 lbs density fiber insulation and fasteners for service and access to internal parts. Unit shall be downflow/upflow arrangement with return air in top/bottom front and supply air out bottom/top of unit. Provide knockouts for electrical and piping connections with the following options.

1. Return air plenum over return air opening.

2. Provide twenty-four (24)/[ ] inch high adjustable floor stands.

3. Provide discharge air turns.

4. Cabinet color shall be Z-0180, light grey/[ ], without/with [ ] accent color.

5. Provide piping access through top of unit and filter plenum/bottom front of unit/bottom side of unit.

6. Provide separation compartment between the piping compressor and air-stream components.

C. Chilled Water Cooling Coil: Construct of copper tubes with aluminum fins. Pressure and leak tested at 1.5 times working pressure, the coil shall be of A-frame design, [ ] rows with a minimum face area of [ ] square feet. The unit coil capacity shall be controlled by a [ ] 300 psig rated, modulating valve. Provide factory piped coil with ball valve, bleed valve, flow switch, piping and 2 way/3-way modulating chilled water valve. Piping shall be arranged to allow unit to be piped from through the top/bottom/front side of the unit casing and prefilter plenum/discharge air plenum section. Provide stainless steel condensate drain pan.

O
R

DX Cooling Coil: Constructed of copper tubes and aluminum fins. Pressure and leak tested at 1.5 times working pressure, the coil shall be of A-frame design, [ ] rows with minimum face area of [ ] square feet. The unit coil capacity shall be controlled by expansion valve. Provide compressor crankcase heaters.

D. Pre-piped coil shall be arranged to allow unit to be piped from through the top/bottom/front side of the unit casing and prefilter plenum section/discharge air plenum section. Provide stainless steel condensate drain pan. All factory provided piping, valves and fittings shall be insulated with minimum of 1" thick, 25/50 rated, fiberglass pipe insulates as specified in Section 23 07 00.

E. Water Cooled Condensers: The water cooled condensers for each circuit shall be cleanable, shell and tube, counterflow type with removable heads. Condenser shall be A.S.M.E. stamped for a maximum refrigerant pressure of 400 PSI at 300 degrees F. The unit shall require the GPM of the temperature water and have a maximum drop as scheduled on the drawings. The condenser circuit shall be pre-piped with a 2-way, 300/150 psig regulating valve which is head pressure activated.

F. Glycol Cooled Condensers: The complete hot gas reheat system shall include a copper tube, aluminum fin coil, three-way solenoid valve and refrigerant check valve. The capacity of the coil shall be [ ] BTU/HR. The water regulating valves shall be pre-piped with head pressure activated 3-way/2-way with bypass regulating valve, with maximum water pressure of 150/300 PSI. The glycol cooled condensers for each circuit shall be cleanable, shell and tube, counterflow type with removable heads. The condenser shall be A.S.M.E. stamped for a maximum pressure of 400 PSI at 300 degrees F. Each condenser circuit shall be prepiped with head pressure activated regulating valve and parallel bypass valve. The unit shall require the GPM and maximum pressure drop as scheduled on the drawings. The dry cooler shall be the low profile, slow speed, multiple, direct drive propeller fan type. The dry cooler shall be constructed of aluminum and contain copper tube aluminum fin coil with an integral electric control panel and disconnect switch. The dry cooler shall be designed for [ ] degrees F. ambient. This system shall be provided with a single/dual centrifugal pump(s) mounted in a weather proof and vented enclosure. The pump(s) shall each be rated for the GPM and

feet of head scheduled on the drawings. Dual pump package shall include a lead/ lag switch. Glycol coil shall be copper tube, aluminum fin coil located in the return air before the A-frame coil. The coil shall be rated at the BTU/HR sensible cooling capacity with a 45 degrees F entering glycol solution temperature as scheduled on the drawing. The glycol coil shall require the GPM and total pressure drop when in the Econ-O-Cycle mode operation as scheduled on the drawing. The complete glycol cooled hot gas reheat system shall include a copper tube aluminum fin coil, three-way solenoid valve and refrigerant check valve. The capacity shall be [ ] BTU/HR.

G. Air Cooled Condenser: The air cooled condenser shall be the low profile, slow speed, multiple direct drive propeller fan type. The condenser shall have two separate refrigeration circuits rated at [ ] degrees F ambient. The condenser shall be constructed of aluminum and contain a copper tube, aluminum fin coil arranged for vertical/horizontal air discharge. The winter control system for the air cooled condenser shall be Fan Speed Control and operate at -20 degrees F ambient. Variable speed motor shall be designed with ball bearings, permanent lubricated, internal overload protection, 40 degrees C rise at full speed, 65 degrees C rise at 10 RPM. The control system shall be complete with transducers, thermostats and electrical control circuit, factory pre-packaged in the integral condenser control box. The winter control system for the air cooled condenser shall be Lee-Temp. and shall allow start-up and positive head pressure control with ambient temperature at -30 degrees F. The package shall include, for each circuit, factory insulated receivers, pressure relief valves, head pressure three-way control valves and roto lock valves for isolating the refrigerant charge. Receivers shall be factory mounted ready for field connection to the air cooled condenser. The heater shall require separate power supply. Provide a factory mounted and wired disconnect switch for condenser control panel accessible from the exterior.

H. Compressors: The compressors shall be Semi-Hermetic type located in a separate compartment with a suction gas cooled motor, vibration isolators, thermal overloads, oil sight glass, manual reset high pressure switch, pump down low pressure switch, suction line strainer, reversible oil pumps and maximum operating speed of 1750 RPM. Each refrigeration circuit shall include hot gas mufflers, liquid line filter dryers, refrigerant sight glass with moisture indicator, adjustable externally equalized expansion valve and liquid line solenoid valve.

I. Fans: Provide 1750 RPM, double-inlet, forward curved, centrifugal fans with adjustable belt drive and slide base. Provide 100,000 hours self-aligning, lubricated fan and motor bearings, and thermal overloads in motor.

J. Filters: Provide 2" thick fiberglass, throwaway pre-filters and [4"] [ ] thick [30%] [ ] pleated, [medium] [ ] efficiency throwaway final-filters (ASHRAE 52-76).

K. Humidifier: Provide units with Armstrong steam grid, steam separator type with internal drying chamber and steam jacketed stainless steel distribution manifold. Complete system shall include pre-piped solenoid control valve, F & T steam trap and cleanable Y-strainer. All mechanical control components shall be located in a separate compartment, isolated from the air stream. Each humidifier shall have a capacity of [ ] lbs per hour at [ ] psig steam supply pressure. Infrared type with high intensity quartz lamps, serviceable stainless steel evaporator pan, prepiped for final connector and automatic water supply system with adjustable water-overfeed. The humidifier shall have a capacity of [ ] lbs/hr using a [ ] kw electric element.

L. Electric Heating Coil: Provide [ ] stage [ ] Kw electric heating coil with built-in auto-reset thermal overload protection wired into the control circuit and manual-reset thermal overload protection wired into the power circuit. Controlling contactors shall be mercury relay type and shall be wired so as to de-energize the heater circuits. All contactors and over current

protection devices shall be factory wired and installed in accordance with the National Electric Code, and National Fire Protection Association, and Underwriters' Laboratories.

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Steam Reheat Coil: The steam reheat coil shall have copper tubes and aluminum fins with a capacity of [ ] BTU/HR with [ ] PSIG steam. The coil shall be factory pre-piped with 2-way modulating control valve, Y-strainer and F & T steam trap.

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Hot Water Reheat Coil: The hot water reheat coil shall have copper tubes and aluminum fins with a capacity of [ ] BTU/HR with [ ] degrees F entering water temperature and [ ] GPM at [ ] PSI pressure drop. The coil shall be factory pre-piped with a 2-way modulating control valve and cleanable Y-strainer.

M. Condensate Pump: The condensate pump shall have a capacity of 145 GPH at 20 foot head complete with integral float switch, pump, motor assembly and reservoir.

N. Liquid-Tect Sensor: Provide [ ] solid state water sensor(s) under the unit/raised floor.

O. Floor Stand: The floor stand shall be constructed of a heliarc welded tubular steel frame, shall have adjustable legs with vibration isolation pads factory supplied, field mounted turning vanes and floor stand shall be [ ] inches high.

EDIT NOTE: Carefully edit and/or select paragraphs P & Q. Coordinate disconnect with Electrical Engineer as required.

P. Disconnect Switch(es): The non-locking/locking type non-automatic molded case circuit breaker shall be mounted in the high voltage section of the electrical panel. The switch shall be accessible from the outside of the unit with the accent panel closed and prevent access to the high voltage electrical components until switched to the "OFF" position. Electrical panel shall be in accordance with UL requirements, pre-wired and tested. Comply with N.E.C. and local codes.

Q. HOA Switches: HOA Switches shall be maintained contact pushbuttons with pilot lights. Provide with trip free thermal overload relays, each phase. Provide interlocks for switches and similar devices for coordination with other Divisions 23 through 25 control sections. Refer to Section 23 05 13 for additional HOA requirements.

R. Firestat: The firestat shall shut down the environmental control system when activated and shall be mounted in the electrical panel with sensing element in the return air compartment.

S. Smoke Detector: The smoke detector shall shut down the environmental control system, activate the alarm system when activated and shall be mounted in the electrical panel with sensing element in the return air compartment.

T. Temperature and Humidity Recorder: Provide a 7-day/24-hour temperature and humidity recorder of the full scope, two pen, surface mounted type with 100 recording charts, one red and on blue bottle of recording ink and single phase power supply.

U. Control Processor (Level 0): The control system shall be microprocessor based. The system shall be provided with two 0.43 inch high, seven segment LED numerical display to allow observation of room temperature and humidity and each setable function:

1. Temperature Setpoint $65^{o}$-$85^{o}$F.

2. Temperature Sensitivity +1° +5°F.

3. Humidity Setpoint 40-60% R.H.

4. Humidity Sensitivity +1% + 10%.

5. Humidifier Flush Rate.

6. Normal Operating Modes (Heating, Cooling, Humidification/ Dehumidification) shall be indicated by colored LEDs on the unit mounted display panel.

7. The control system shall monitor unit operation and activate an audible and visual alarm in the event the following factory present alarm conditions:
   a. High Temperature
   b. Low Temperature
   c. High Humidity
   d. Low Humidity
   e. Change Filters
   f. Loss of air

8. A common alarm light shall be activated when any of the above conditions exist and indicate high head pressure and water under floor.

9. A compressor sequence shall be provided to change the lead/lag sequence of the compressors.

10. Panel shall have start-stop push buttons.

11. Provide hand-off-auto switch to allow the unit to override the Building DDC System.

12. Provide Sitemaster having the capacity to monitor the operation of up to 24 environmental control or power conditioning systems. The 9" CRT display shall be provided in English. The Sitemaster shall have the capability to access and change (at the user direction) the temperature and humidity setpoints and sensitivities of each unit. The printer shall provide chronological alarm information and shall also be capable of being programmed to print out environmental conditions or operating modes at each unit.

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The Control System shall be microprocessor based and allow programming of temperature and humidity setpoints, alarm parameters, provide monitoring of operational status and maintain a data-base of room conditions and environmental system operational status and allow programming of the following room conditions.

13. Temperature Setpoint (65-85°F)

14. Temperature Sensitivity +1-+5°F in 0.1°F increments)

15. Humidity Setpoint (40-60% RH)

16. Humidity Sensitivity (+1-+10% RH in 0.1% increments)

17. All setpoints shall be adjustable from the individual unit front monitor panel, hand-held Service Terminal, or Site Monitoring Device.

18. The control system shall be capable of predictive control of temperature and humidity..

19. The microprocessor shall be capable of responding to varying rates of temperature change in the room. The control system shall delay heating or cooling in response to very low rates of change, shall advance heating or cooling in response to rapid temperature changes, calculate the moisture content in the room, prevent unnecessary humidification and dehumidification cycles by responding to changes in dewpoint temperature, and provide the following internal controls:
    a. Prevent compressor short-cycling by incrementally expanding the control hysteresis of the compressor stages when compressor cycles approach 10 cycles per hour. Timer-based short-cycle controls are unacceptable.
    b. Automatically change the lead/lag sequence of the compressors after each start.
    c. For start-up after power failure, the system shall provide automatic restart with a programmable (up to 10 minutes in 6-second increments) time delay from either the unit or from the central site monitoring system.
    d. During start-up, or after power failure, sequence operational load activation to minimize inrush current. Systems allowing multiple loads to start simultaneously are unacceptable.
    e. Chilled water and hot water coils automatically flushed to prevent the build-up of contaminants.
    f. Provide a monitor panel to display operational status, alarms and permit calibration and programming of operation parameters. All indicators shall be in language form. No symbols or codes shall be acceptable.
    g. The front monitor panel shall be provided with a three-digit, 0.43 inch high, seven- segment LED numerical display to indicate temperature, humidity, percent capacity (cooling, heating, humidification de-humidification, and econ-o-cycle), temperature and humidity setpoints and sensitivities, and humidifier flush rate. Operational Status (Heating, Cooling, Humidification and Dehumidification) and alarm conditions shall be indicated by colored LED's.
    h. Activate an audible and visual alarm in event of any of the following conditions:
        1) High Temperature
        2) Low Temperature
        3) High Humidity
        4) Low Humidity
        5) High Compressor Head
        6) Pressure (Compressorized Systems Only)
        7) Humidifier Problem
        8) Loss of Air Flow
    i. Provide four customer accessible local alarms to be indicated on the front panel capable of being programmable activation time delays.
    j. The audible alarm shall have adjustable volume.
    k. Common alarm shall be provided to interface selected alarms with a remote alarm device.
    l. All alarms shall be communicated to the Site monitoring system with the following information: Date and time of occurrence, unit number and present temperature and humidity.
    m. Provide the capability of maintaining a log of system performance and environmental conditions communicated and displayed at a remote monitoring and control device with the following information included in the log, complete with time and date:
    1) Temperature (present, minimum and maximum for last 24 hours)
    2) Humidity (present, minimum and maximum for last 24 hours)
    3) Compressor Operating Hours Alarm Occurrence
    n. All electronic circuitry shall be provided with self-diagnostics for troubleshooting. Each printed circuit board shall be diagnosed and reported as pass/not pass.

o. The microprocessor shall be compatible with all remote monitoring and control devices.

p. Provided Sitemaster having the capacity to monitor the operation of up to 24 environmental control or power conditioning systems. The Sitemaster shall display unit operating mode and alarm conditions on a 9" CRT display. The display shall be provided in English. The Sitemaster shall have the capability to access and change (at the discretion of the user) the temperature and humidity setpoints and sensitivities of each unit. The printer that shall provide the user with chronological alarm information capable of being programmed to print out environmental conditions or operating modes at each unit, as well as a summary of environmental information which shall include:
   1) Daily Compressor Run
   2) Time
   3) Present Temperature
   4) Present Humidity
   5) Daily High Temperature
   6) Daily Low Temperature
   7) Daily Low Humidity
   8) Daily Low Humidity
   9) Present Average Temperature
   10) Present Average Humidity

V. Service Terminal: Provide [___] service terminal(s) to be used to monitor, program or troubleshoot the system.

W. Testing and Certification: All equipment shall be factory run and tested with certified test data furnished.

PART 3 - EXECUTION:

3.1 INSPECTION:

A. General: Examine areas and conditions under which computer room air conditioning units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF COMPUTER ROOM AIR CONDITIONING UNITS:

A. General: Install computer room air conditioning units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

B. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.

C. Ductwork: Refer to Section 23 31 13 "Metal Ductwork". Connect supply and return ducts to computer room air conditioning units with flexible duct connections. Provide transitions to exactly match unit duct connection size.

D. Water Glycol Cooled Condenser Piping: Refer to Section 23 20 00 "Basic Piping Materials and Methods". Connect supply and return piping to units as indicated, with unions and shutoff valves and accessories.

E. Hot Water Heating Coil Piping: Refer to Section 23 20 00 "Basic Piping Materials and Methods". Connect supply and return piping to hot water coil as indicated, with unions and shutoff valves and accessories.

F. Steam Heating Coil Piping: Refer to Section 23 22 16 "Steam Specialties". Connect steam and condensate piping in steam coil as indicated, with thermostatic steam trap, unions and shutoff valves.

G. Drain Piping: Connect condensate pump drain pan to nearest indirect waste connection, or as indicated.

3.3 FIELD QUALITY CONTROL:

A. General: Start-up computer room air conditioning units, with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

3.4 CLOSEOUT PROCEDURES:

A. Training: Provide services of manufacturer's technical representative for 1-half day to instruct Owner's personnel in operation and maintenance of computer room air conditioning units.

1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.5 SPARE PARTS:

A. General: Furnish to Owner, with receipt, the following spare parts:

1. One set of matched fan belts for each belt driven fan.
2. One set of Pre and final filters for each unit.

**END OF SECTION 23 81 23**

# SECTION 23 82 00 – TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of terminal unit work is indicated on drawings and schedules, and by requirements of this section.

B. Types of terminal units required for the project include the following:

1. Baseboard radiation.
2. Finned tube radiation.
3. Convectors.
4. Unit heaters.
5. Cabinet unit heaters.
6. Fan-coil units.
7. Vertical air handlers.
8. Unit ventilators (not acceptable).
9. Coils.
10. Electric wall heaters.
11. Electric radiant ceiling panel heaters.
12. Toe space heater.
13. Electric ceiling heater/exhaust fan/light.
14. Radiant-acoustical ceiling panels (hot water).
15. Electric duct heaters.

C. Refer to other Divisions 20 through 25 sections for piping; ductwork; testing, adjusting and balancing of terminal units; not work of this section.

D. Refer to Division 26 for the following work; not work of this section.

1. Power supply wiring from power source to power connection on terminal units.

2. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections:
   a. Control wiring between field-installed controls, indicating devices, and terminal unit control panels.
      1) Control wiring specified as work of Section 23 09 23 for Direct Digital Control Systems is work of that section.

E. Refer to other Section 23 09 23 and other Division 23 sections for automatic temperature controls not factory installed, required in conjunction with terminal units; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of terminal units, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.

2. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".

3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".

4. ARI Compliance: Test and rate fan-coil units in accordance with ARI Standard 440 "Room Fan-Coil Air Conditioners".

5. UL Compliance: Construct and install fan-coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units".

6. UL Compliance: Provide electrical components for terminal units, which have been listed and labeled by UL.

7. AGA Compliance: All gas-fired heating equipment shall be AGA Design Certified.

8. Electric Heating Equipment: All equipment with a heating coil capacity exceeding a 48 amp rating shall have the heating elements subdivided and protected by an overcurrent protection device rated at not more than 60 amps. Equipment not exceeding 48 amps shall also have overcurrent protection. Overcurrent protection devices shall be factory wired and installed in accordance with the National Electric Code. All equipment shall be factory assembled and wired in accordance with the National Fire Protection Association and shall be listed by Underwriters' Laboratories.

## 1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, for terminal units showing dimensions, capacities, ratings, performance characteristics, gauges and finishes of materials, and installation-startup instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating terminal unit dimensions, weight loading, required clearances, construction details, field connection details and methods of assembly of components.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

E. Samples: Submit 3 samples of each type of cabinet finish furnished.

F. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, control, accessories, "trouble-shooting" maintenance guide, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

## 1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.

B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Baseboard Radiation

a. American Air Filter
b. Trane
c. Slant/Fin Corp.
d. Vulcan
e. Sterling Radiator; Div. of Reed National Corp.
f. Weil-McLain, Marley Co.

2. Finned Tube Radiation

a. American Air Filter
b. Trane
c. Dunham-Bush, Inc.
d. Slant/Fin Corp.
e. Vulcan
f. Sterling Radiator; Div. of Reed National Corp.

3. Convectors

a. American Air Filter
b. McQuay
c. Vulcan
d. Burnham Corp.; Hydronics Div.
e. Dunham-Bush, Inc.
f. Trane

4. Unit Heaters

a. American Air Filter
b. McQuay
c. Airtherm Mfg. Co.
d. Vulcan
e. Dunham-Bush, Inc.
f. McQuay Inc.
g. Modine Mfg. Co.
h. Trane

5. Cabinet Unit Heaters

a. American Air Filter
b. McQuay
c. Airtherm Mfg. Co.
d. Dunham-Bush, Inc.
e. Trane
f. Vulcan

6. Fan Coil Units

a. American Air Filter
b. McQuay
c. Trane
d. York; Div. of York International

e. Airtherm Mfg. Co.
f. Dunham-Bush, Inc.
g. International Fan Coil

7. Vertical Air Handlers

a. Airedale
b. Temspec
c. Change'Air

8. Coils:

a. Aerofin Corp.
b. Dunham-Bush, Inc.
c. McQuay Inc.
d. Trane (The) Co.
e. York; Div. of York International

9. Electric Baseboard Radiation (not acceptable)

10. Electric Cabinet Heater (prefer not to use)

a. Airtherm
b. Trane
c. Q Mark
d. Berko
e. Markel
f. Singer
g. Raywall

11. Electric Unit Heater (prefer not to use)

a. Trane
b. Airtherm
c. Q Mark
d. Singer
e. Brasch
f. Indeeco
g. Berko
h. Markel
i. Modine
j. Raywall

12. Electric Convector (prefer not to use)

a. Trane
b. Q Mark
c. Singer
d. Berko
e. Markel
f. Raywall

13. Electric Wall Heaters (prefer not to use)

a. Berko
b. Q Mark
c. Singer
d. Brasch
e. Markel
f. Raywall

14. Electric Radiant Ceiling Panel Heater (prefer not to use)

a. Aztec

b. Berko
c. Q Mark
d. Singer
e. Markel
f. Raywall

15. Toe-Space Heater

a. Berko
b. Q Mark
c. Nutone
d. Singer
e. Markel

16. Electric Ceiling Heater/Exhaust Fan/Light

a. Markel
b. Q Mark
c. Raywall

17. Radiant-Acoustical Ceiling Panels (Hot Water)

a. Airtex
b. Aero Tech Mfgr Co.

18. Electric Duct Heaters

a. Brasch
b. Q Mark
c. Indeeco
d. Markel
e. Raywall

2.2 BASEBOARD RADIATION:

A. General: Provide (hot water) (steam) (electric) baseboard radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum 20-ga cold-rolled steel, one-piece back and top panel, front panel with integral damper. Provide steel brackets inserted in back/top panel, to support element and front panel. Provide standard/custom/prime coat baked enamel finish on topside and front panel only.

C. Elements: Copper tube and aluminum fins, with slide mechanism between element and support brackets to eliminate expansion and contraction noises.

D. Accessories: Provide the following accessories:

1. End panels, inside and outside corners, and enclosure extensions.
2. Removable 18" long cover access section in front of valves, balancing cocks, and traps.
3. Factory-mounted dampers.
4. Sill extensions.
5. Mullion channels.
6. Pilaster covers.

2.3 FINNED TUBE RADIATION:

A. General: Provide (hot water) (steam) finned tube radiation of lengths, wall to wall enclosure, in locations as indicated, of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum 18/16/14 ga. cold-rolled steel, continuous 20-ga. partial height/full height backplate, minimum 16/18/14 ga. front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.

C. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.

D. Finish: Unfinished zinc coated steel/flat black heat resisting paint backplate, standard factory color selected baked enamel finish/[custom color as selected by Architect in baked enamel finish on front, sides, top and accessories.

E. Accessories:

1. End panels, inside and outside corners, and enclosure extensions.
2. Removable 18" long hinged cover access section in front of valves, balancing cocks, and traps.
3. Factory-mounted dampers.
4. Sill extensions.
5. Mullion channels.
6. Pilaster covers.

## 2.4 CONVECTORS:

A. General: Provide hot water/steam convectors having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum (14) 16-ga steel front and top panels, (14) 18-ga side panels, and 20-ga back panels. Phosphatize and galvanize back panels, phosphatize and standard/custom/ color baked enamel finish top, sides, and front, with one coat of primer. Secure fronts in place with quick opening slide bolts or camlock fasteners.

1. Recessed Cabinets: One-piece front panel, with 4-side gasketed overlap.

C. Elements: Aluminum fins, ribbed steel side plates, fin tube supports and copper tubes, cast-iron headers. Factory-test each element to 150 psi air pressure under water.

D. Accessories: Provide the following accessories:

1. Factory-mounted dampers.
2. 1/2" insulation on cabinet back.
3. Access doors in front for valve access.

## 2.5 UNIT HEATERS:

A. General: Provide unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Horizontal Unit Heaters:

1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Provide motor- mounted panel, minimum of 18-ga steel. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for 4-way air diffusion.

2. Fans: Construct of aluminum, and factory-balance. Provide fan inlet orifice, smooth and drawn into casing back panel.

C. Vertical Unit Heaters:

1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Design casing to enclose fan, motor and coil, design fan orifice formed into discharge panel. Provide air diffusers as scheduled.

2. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.

D. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in steam/hot water applications.

E. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

## 2.6 CABINET UNIT HEATERS:

A. General: Provide hot water/steam cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.

B. Chassis: Galvanized steel wrap-around structural frame with edges flanged.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: 16-ga removable front panel, 18-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish/Custom color as selected by Architect in baked enamel finish.

E. Water Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.

F. Steam Coils: Construct of 1" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 75 psi and leak test at 450 psi under water. Provide cast-iron headers, and same end connections for supply and return.

G. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass- reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.

H. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit.

I. Filters: Provide 1" thick throwaway type filters in fiberboard frames.

J. Accessories: Provide the following accessories as indicated and/or scheduled:

K. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.

1. Recessing Flanges: Provide 18-ga steel flanges for recessing cabinet heaters into wall or ceiling.

2. Sub-bases: Provide 18-ga steel sub-base for vertical units, height as indicated.

3. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.

## 2.7 FAN-COIL UNITS:

A. General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coils, fanboard, drain pan assembly, fans, housing, motor, filter, and insulation.

B. Chassis: Construct chassis of galvanized steel with flanged edges.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: Construct of 18-ga steel removable panels, 16-ga front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer. Standard factory color selected baked enamel finish./ Custom color as selected by Architect in baked enamel finish.

E. Coils: Construct of 1/2" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 250 psi working pressure, and leak tested at 350 psi under water.

F. Auxiliary Heating Coils: Construct of 1/2" seamless copper tubes mechanically bonded to configurated aluminum fins. Design for 250 psi working pressure.

G. Drain Pans: Construct of galvanized steel. Insulate with polystyrene or polyurethane insulation. Provide drain connection.

H. Fans: Provide centrifugal forward-curved double-width wheels of reinforced fiberglass, in galvanized steel fan scrolls.

I. Motors: Provide motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords.

J. Filters: Provide 1" thick throwaway type filters in fiberboard frames.

K. Dampers: Provide 18-ga steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electric operators for 25% open cycle.

L. Accessories: Provide the following accessories as indicated and/or scheduled:

1. Wall Boxes: Provide aluminum wall boxes with integral eliminators and insect screen.

2. Discharge Grille Panels: Provide 18-ga galvanized steel, stamped integral grilles, with access doors.

3. Sub-Bases: Provide 18-ga steel sub-base, height as indicated.

4. Extended Oilers: Provide plastic motor oiler tubes extending to beneath top discharge grille.

5. Recessing Flanges: Provide 18-ga steel flanges for recessing fan-coil units into wall or ceiling.

## 2.8 VERTICAL AIR HANDLERS:

A. General: Provide vertical air handlers having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit cabinets, dampers, fan board assembly, motors, coils, filters, drain pans, outdoor air intake and specified accessories.

B. Cabinets: Construct of 16-ga furniture steel with exposed edges rounded. Provide removable front. Clean, phosphatize and flow-coat with baked-on primer paint steel surfaces/standard factory color selection baked enamel finish. Color as selected by Architect/Engineer. Provide discharge air grille integral with unit and cleanable sight block-offs below grille. Provide completely removable panel(s) for access to piping and valves. Provide leveling legs. Provide pipe access openings in bottom of cabinet and pipe chase across back of unit for crossover piping and wiring. Unit inlet grilles or access panel shall be removable for filter access.

C. Dampers: Provide dual-blade type mixing dampers for modulation of return and outside air. Provide sealing device on damper edges and ends. Bypass dampers shall be aluminum, insulated and tight sealing.

D. Fan Board Assembly: Provide single rigid assembly including fans, fan housings, bearings, fan shaft and motor. Mount fan assembly on rubber isolators. Wrap-around portion shall be 3/4", 6 lbs density, molded fiberglass and vinyl coated exterior surface.

E. Motors: Provide permanent split-capacitor type with [two-speed] [variable-speed] motors. Provide multiple tap auto transformer wired to motor.

F. Coils: Construct hydronic coils of 5/8" copper tubes with plate-type heavy gauge aluminum fins with crack-free continuous fin collars. Drain pan shall be deep-formed galvanized steel internally lined with closed cell inert plastic insulating material.

G. Refrigeration (where required): Construct direct expansion coils of 2-row copper tubes and aluminum fins, conforming to ARI 210. Provide factory-installed thermal expansion valve, refrigerant filter/dryer, and R-22 holding charge. Provide condensing units equipped with built-in suction line accumulator, anti-slugging devices, crank-case heater, filter-drier, winding thermostat, current overload protection, pressure limiting valve, and electrical control panel. Also equip with sweat connection special adapters, service valves, and sight glass. Provide start-capacitor kit.

H. Accessories: Provide the following accessories as indicated and/or specified:

1. Filters: Provide 1" thick throwaway/permanent/replaceable media filters.

2. Wall Louvers: Provide wall louvers for outside air intake, vertical blade design with channels and constructed of heavy-gauge aluminum.

3. Crossover Piping: Provide in cabinet pipe chase crossover piping of size and configuration as indicated on drawings.

## 2.9 COILS:

A. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARI 410.

B. Heating Coils:

1. Fins: Construct of continuous aluminum or copper configurated plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.

2. Tubes: Construct of copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leak-tight joint.

3. Headers: Construct of gray cast iron for coils 33" high and smaller. Hydrostatically test to 400 psi before assembly. Construct of round seamless copper tube for coils over 33" high.

4. Casings: Construct of 16-ga continuous coated galvanized steel with fins recessed into channels to minimize air bypass.

5. Testing: Proof test coils at 300 psi, leak test at 200 psi under water.

6. Coil Types: Provide the following coil types as indicated, and as scheduled.

a. Hot Water to 200 psi, 220 deg. F (104 deg. C): Provide 2-row, 5/8" tubes, same-end connection coil. Provide rolled tube-to-header joints for coil heights 33" and smaller. Provide brazed tube-to-header joints for coil heights over 33".
b. Hot Water to 225 psi, 325 deg. F (163 deg. C): Provide 2-row, 5/8" tubes, same- end connection, dual-tube-feed coil. Reinforce tube-to-header joints with brass bushings and provide expanded joints.
c. Hot Water to 225 psi, 325 deg. F (163 deg. C) and Steam to 200 psi, 400 deg. F (204 deg. C): Provide 2-rows, 5/8" tubes, single tube continuous circuit, same-end connection coil. Roll connection tube.
d. Steam to 200 psi, 400 deg. F (204 deg. C): Provide 2-rows 5/8" tubes, same-end connection coil. Reinforce tube joints with brass bushings. Provide steam deflectors opposite supply connection.
e. Steam to 200 psi, 400 deg. F (204 deg. C): Provide 2-rows, 1" tubes, same-end connections, steam distributing tube type coil. Locate distributing tube concentrically within condensing tube supported by corrosion-resistant clips. Provide steam deflectors opposite supply connection.

C. Cooling Coils:

1. Fins: Construct of continuous aluminum or copper configurated plate-fin type with full fin collars for accurate fin spacing and maximum fin-tube contact.

2. Tubes: Construct of 5/8" seamless copper tubes, arranged in parallel pattern with respect to air flow.

3. Casings: Construct of 16-ga continuous coated galvanized steel for coil heights 33" and smaller; 14-ga for coil heights over 33". Provide formed end supports and top and bottom channels. Provide 16-ga steel center tube support for coil lengths 42" to 96", 2 or more supports for coil lengths over 96".

4. Air Bypass Arrestor: Provide foam sealing strip located between casing channels and fins along top and bottom.

5. U-Bends: Construct of 5/8" copper tubes, machine die- formed on each end to provide accurate fit for silver brazed joints.

6. Testing: Proof test water coils at 300 psi and leak test at 200 psi under water. Proof test refrigerant coils at 450 psi and leak test at 300 psi under water; clean, dehydrate and seal with dry nitrogen charge.

7. Coil Types: Provide the following coil types as indicated, and as scheduled:
   a. Cleanable and Drainable Water Coils: Provide close-grained gray cast-iron inlet, outlet, and removable headers. Bolt headers to flat steel plates with gaskets. Roll tubes into steel plates and headers.
   b. Drainable Water Coils: Provide close-grained gray cast-iron inlet, outlet, and intermediate headers.
   c. Standard Water Coils: Provide close-grained gray cast-iron inlet and outlet headers for coil heights 33" and smaller. Provide seamless copper tube headers for coil heights over 33".
   d. Refrigerant Coils: Provide refrigerant distributor of Venturi type with low pressure drop design, arranged for down feed and maximum of 12 circuits per distributor. Provide seamless copper tube suction header. Construct distributor tubes of 5/16" copper tube for R-12, 1/4" copper tube for R-22.

8. Cooling coils shall be capable of operating at face velocities up to 600 FPM without moisture carryover. Coat fins with fin coating to prevent moisture carryover. Any coils found to have excessive moisture carryover during system operation shall be corrected by the manufacturer at no cost to the Owner.

9. Evaporative Section: Provide an evaporative section, over a common pan section with the cooling coil. This section shall be constructed with the coil preceding the evaporative section in the direction of air flow. The "Munters Fill" type media is to be 12" deep, in the direction of air flow. Section is to be complete with distribution pipe and header with a connection point in the center of the header for a 3/4" copper pipe. Media is to have a saturation efficiency of 89% at 500 feet per minute face velocity.

| Edit Note: Select Coated Steel or Stainless Steel |
|---|

10. Pan: The pan under the cooling coil and the evaporative section shall be 1/8" MOH HRS plate/heavy gauge 304 stainless steel continuously welded. Pan to be a minimum of 12" deep with drain coupling welded to the structural support. Finish inside of pan with three coats of zinc impregnated submarine primer (ZIPCOR) for MOH HRS.

11. Evaporative Section Casing: Provide a casing enclosure of heavy gauge galvanized iron with the inside surface painted with two coats of "ZIPCOR".

OR

Heavy gauge 304 stainless steel.

## 2.10 ELECTRIC BASEBOARD RADIATION:

A. General: Provide electric baseboard radiation of lengths, in locations as indicated, of capacities, style and having accessories as scheduled.

B. Cabinets: Minimum 18-ga. cold steel, front cover brackets, junction box and built-in wireway the length of the heater. Provide standard/custom baked enamel finish.

C. Elements: Electric resistance heating element, full length auto-reset thermal overload disconnect switch, junction boxes at both ends of each section, (unit mounted thermostat) (low voltage transformer/relay section).

D. Accessories: Provide the following accessories:

1. End panels.

2.11 ELECTRIC CABINET HEATERS:

A. General: Provide electric cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.

B. Chassis: Galvanized steel wrap-around structural frame with edges flanged.

C. Insulation: Faced, heavy density glass fiber.

D. Cabinet: 16-ga removable front panel, 8-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer/standard factory color selected baked enamel finish/custom color as selected by Architect in baked enamel finish.

E. Electric Element: Electric resistance element with manual-reset thermal overload protection, (unit mounted thermostat) (unit mounted contactors and transformer).

F. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass- reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.

G. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit.

H. Filters: Provide 1" thick throwaway type filters in fiberboard frames.

I. Accessories: Provide the following accessories as indicated and/or scheduled.

1. Wall boxes: Provide aluminum wall boxes with integral eliminators and insect screen.

2. Recessing Flanges: Provide 18-ga steel flanges for recessing cabinet heaters into wall or ceiling.

3. Sub-bases: Provide 18 ga steel sub-base for vertical units, height as indicated.

2.12 ELECTRIC UNIT HEATERS:

A. General: Provide electric unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Horizontal Unit Heaters:

1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Provide motor-mounted panel, minimum of 18-ga steel. Fabricate casing to enclose coil, louvers, and fan blades. Provide louvers for 2-way air diffusion.

2. Fans: Construct of aluminum, and factory-balance. Provide fan inlet orifice, smooth, and drawn into casing back panel.

C. Vertical Unit Heaters:

1. Casings: Construct of steel, phosphatized inside and out, and finished with standard color baked enamel finish. Design casing to enclose fan, motor, and coil, design fan orifice formed into discharge panel. Provide air diffusers as scheduled.

2. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.

D. Elements: Unit shall include electric resistance element with manual-reset thermal overload protection, (unit mounted thermostat) (unit mounted contactors and transformer).

E. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.

## 2.13 ELECTRIC CONVECTORS:

A. General: Provide electric convectors having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled.

B. Cabinets: Minimum (14) 16-ga steel front and top panels, (14) 16-ga side panels, and 20-ga back panels. Phosphate and galvanize back panels, phosphatize and standard/custom color baked enamel finish top, sides, and front, with one coat of primer. Secure fronts in place with quick opening slide bolts or camlock fasteners.

C. Elements: Heating element shall have full length auto-reset thermal overload disconnect switch, line voltage safety disconnect switch, (unit mounted thermostat).

D. Accessories: Provide the following accessories:

1. Factory-mounted dampers.
2. 1/2" insulation on cabinet back.
3. Access doors in front for valve access.

## 2.14 ELECTRIC WALL HEATER:

A. Unit shall include electric resistance type heating elements visible/concealed adjustable thermostat, concealed electrical connections, line voltage disconnect enclosed fan motor and wall box.

B. Unit shall be standard color baked enamel finish.

## 2.15 ELECTRIC RADIANT CEILING PANEL HEATER:

A. Panel shall fit a standard 2' x 4' lay-in ceiling grid. Provide mounting kit. Panel finish shall be off-white. Panel shall be UL approved, baked enamel finish (with silk screened fissured pattern) to match ceiling finish.

B. Panel shall include 3'' fiberglass pad above heating element.

C. Panels shall have a five (5) year warranty.

## 2.16 TOE-SPACE HEATER:

A. Unit shall be designed for installation in cabinet toe-space. Unit shall be UL labeled.

B. Unit shall include steel housing, integral inlet and discharge grille, electric heating element with thermal overload protection, five (5) year warranty on heating element, centrifugal fan, unit mounted thermostat. Motor/fan assembly shall be vibration isolated.

C. Unit shall be standard color baked enamel finish.

2.17 CEILING HEATER/EXHAUST FAN/LIGHT:

A. Unit shall be UL labeled and shall be HVI tested and certified to comply with HUD standards.

B. Unit shall include fan(s), exhaust backdraft damper, wall/roof cap, automatic thermal overload protection, heating element, wall switch with separate on-off/timer controls for heat, exhaust and light. Motor/fan assembly shall be vibration isolated.

C. Unit shall be standard color baked enamel finish.

2.18 RADIANT-ACOUSTICAL CEILING PANELS:

A. The radiant acoustical panels shall be placed into a standard grid system to be provided by the General Contractor in accordance with the Architect's reflected ceiling plans.

B. Provide 1/2" O.D., Type "L" copper loops for interconnection of panels.

C. Radiant panels shall have certified performance data provided by a recognized testing laboratory.

D. Panels shall be finished with standard white paint.

E. Provide supervision by distributor of panels.

2.19 ELECTRIC DUCT HEATERS:

A. Electric duct heaters shall be electric resistance type. Controlling contactors shall be magnetic/mercury relay type and shall be wired so as to de-energize the heater circuits. All contactors and over current protection devices shall be factory wired and installed in accordance with the National Electric Code, the National Fire Protection Association, and Underwriters' Laboratories.

B. Coil shall be non-stratifying design such that each stage of heat is spread over the entire face of the coil.

C. Coil shall have a built-in pressure differential type air flow safety switch and auto-reset thermal overload protection wired into the control circuit, and manual-reset thermal overload protection wired into the power circuit to the coil. Heater shall include line voltage disconnect switch.

D. Provide a built-in fused control power

transformer. PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BASEBOARD RADIATION:

A. General: Install baseboard radiation as indicated, and in accordance with manufacturer's installation instructions.

B. Locate baseboard radiation on outside walls as indicated, run cover continuous wall-to-wall unless otherwise indicated.

C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, or temperature control valve.

## 3.3 INSTALLATION OF FINNED TUBE RADIATION:

A. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.

B. Locate finned tube radiation on outside walls as indicated, run cover wall-to-wall unless otherwise indicated.

C. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.

D. Install end caps where units butt against walls. Install access panels centered in front of each shutoff valve, balancing cock, steam trap, or temperature control valve.

## 3.4 INSTALLATION OF CONVECTORS:

A. General: Install convectors as indicated, and in accordance with manufacturer's installation instructions.

B. Locate convectors as indicated, coordinate with other trades to assure correct recess size for recessed convectors.

## 3.5 INSTALLATION OF UNIT HEATERS:

A. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.

B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.

C. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.

D. Support units with rod-type hangers anchored to building substrate.

E. Install piping as indicated.

F. Protect units with protective covers during balance of construction.

## 3.6 INSTALLATION OF CABINET HEATERS:

A. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.

B. Locate cabinet heaters as indicated, coordinate with other trades to assure correct recess size for recessed units.

C. Install piping as indicated.

D. Protect units with protective covers during balance of construction.

## 3.7 INSTALLATION OF FAN-COIL UNITS:

A. General: Install fan-coil units as indicated, and in accordance with manufacturer's installation instructions.

B. Locate fan-coil units as indicated, coordinate with other trades to assure correct recess size for recessed units.

C. Provide piping as detailed on the drawings.

D. Provide 3/4" condensate drain pipe from unit drain pan connection to nearest adequate floor drain or drain pipe.

E. Protect units with protective covers during balance of construction.

## 3.8 INSTALLATION OF VERTICAL AIR HANDLERS:

A. General: Install vertical air handlers as indicated, and in accordance with manufacturer's installation instructions.

B. Locate vertical air handlers as indicated, level and shim units, anchor to substrate. Coordinate with other trades for exact location of wall louvers.

C. Install piping as indicated.

D. Protect units with protective covers during balance of construction.

E. Install accessories and auxiliary radiation if/as specified; provide wall trim pieces as required.

## 3.9 INSTALLATION OF COILS:

A. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.

B. Mount coils on steel supports to form banks or stacks as indicated, brace, secure to air intake chamber. Place in location to permit installation of bypass damper if required, provide steel baffles where required to prevent bypassing of air.

C. Pitch coil casings for drainage, not less than 1/8" toward return connections, except where drainage feature is included in coil design.

D. Provide for each bank of cooling coils, drain pan(s) under each coil supported off of floor of sufficient height to allow installation of condensate drain pipe trap to allow drainage of condensate from pan when installed on suction side of fan. Provide condensate drain piping from drain pan connection to nearest adequate floor drain. Plug any unused drain connection

E. Provide for each steam coil unit, steam supply connection with strainer, gate valve, automatic temperature regulating valve, condensate return connection with vacuum breaker, f & t trap and gate valve, as indicated.

F. Provide for each hot or chilled water coil unit, water supply, return connection, strainer, gate valves, automatic temperature regulating valve, balancing cocks, as indicated.

G. Provide electric wiring for each electric duct heater in accordance with manufacturer's installation instructions and Division 26.

## 3.10 INSTALLATION OF ELECTRICAL TOE SPACE HEATERS:

A. General: Install electric toe space heaters as indicated, and in accordance with manufacturer's installation instructions.

B. Inspect for damage and verify that nameplate data corresponds with unit designation.

## 3.11 INSTALLATION OF RADIANT CEILING PANELS:

A. General: Install electric/hot water radiant ceiling panels as indicated and in accordance with manufacturers' installation instructions.

B. Inspect for damage and verify that nameplate data correspondence with panel designation.

## 3.12 ELECTRICAL WIRING:

A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.

B. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

## 3.13 ADJUSTING AND CLEANING:

A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.

B. Retouch any marred or scratched surfaces of factory- finished cabinets, using finish materials furnished by manufacturer.

C. Install new filter units for terminals requiring same.

## 3.14 START-UP:

A. Start-up, test, and adjust terminal units in accordance with manufacturer's published start-up instructions and the LPS General Conditions of the Contract. Adjust for proper airflow where applicable.

**END OF SECTION 23 82 00**

# SECTION 23 83 13 - ELECTRIC HEATING CABLES

PART 1 – GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of electric heating cable work is indicated by drawings and schedules and as specified herein.

B. Applications for electric heating cables required for the project include the following:

1. Ceiling heating.
2. Floor heating.
3. Heat-tracing.
4. Hot-water temperature maintenance.
5. Ice-stopping.
6. Snow-melting.

C. Refer to Division 26 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electric heating cables; not work of this section.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data and installation instructions for electric heating cables.

B. Shop Drawings: Submit scaled layout drawings of electric heating cables including, but not necessarily limited to, layout, locations, elevations, wall and floor penetrations, and connections.

C. Record Drawings: At project closeout, submit record drawings; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

D. Wiring Diagrams: Submit wiring diagrams for electric heating cables showing layout, including grid networks and cable runs, of heating cables and associated devices. Include requirements for proper spacing between cables, and show locations of connectors and connections to electrical power feeders. Differentiate between portions of wiring that are manufacturer-installed and portions that are field-installed.

E. Maintenance Data: Submit maintenance data and parts lists for compressed air systems materials and products. Include this data, product data, shop drawings, record drawings, and wiring diagrams in maintenance manual; in accordance with requirements of the LPS General Conditions of the Contract and Divisions 20 through 25.

1.3 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electric heating cables, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer's Qualifications: Firm with at least 2 years of successful installation experience with projects utilizing electric heating cable work similar to that required for this project.

C. Codes and Standards:

1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC as applicable to construction and installation of electric heating cables.

2. UL Compliance: Comply with applicable torquing requirements of UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide electric heating cables and components which are UL-listed and labeled.

3. IEEE Compliance: Comply with applicable recommended installation practices of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings", pertaining to electric heating cables.

4. NEMA Compliance: Provide electric heating cables and accessories which comply with NEMA standards.

1.4 DELIVERY, STORAGE AND HANDLING:

A. Deliver electric heating cables in factory-fabricated type containers or wrappings, which properly protect cables from damage.

B. Store electric heating cables in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. Handle electric heating cables carefully to prevent physical damage to cables and components. Do not install damaged cables; remove from site and replace damaged cables with new.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturers: Subject to compliance with requirements, provide electric heating cables of one of the following (for each type of cable):

1. Raychem Corporation.
2. Easy-Heat WireKraft Div; Bristol Corporation.
3. Thermon
4. Smith-Gates Corporation.
5. Chromalox Div; Emerson Electric Company.

2.2 ELECTRIC HEATING CABLES:

A. Radiant Heating Cables: Provide self-regulating electric radiant heating cables which are suitable for embedment installation in floors or ceilings; of temperature, wattage and voltage ratings indicated. Select heater consisting of 2-16 AWG tinned-copper bus wires parallel embedded in a radiation cross-linked conductive polymer core which varies its power output to respond to temperature along its length, allowing the heater to be crossed over itself without overheating, to be cut to length in the field, and to have no heater-to-cold lead connections buried in the slab. Cover heater with a radiation cross-linked modified polyolefin dielectric jacket and protect with a tinned-copper braid and a polyolefin outer jacket.

B. Radiant Ceiling Heating Cables: Provide electric radiant heating cables which are suitable for ceiling installation; of wattage and voltage ratings, Hz, BTUH's, and for the quantity and lengths indicated. Terminate cables with 7-feet of factory-assembled non-heating leads with connectors.

C. Snow-melting Heating Cables: Provide self-regulating electric heating cables and components suitable for embedment installation in asphalt and concrete paving material. Select heater

consisting of 2-16 AWG tinned-copper bus wires parallel embedded in a self-regulating polymer core which varies its power output to respond to temperature along its length, allowing the heater to be crossed over itself without overheating, to be cut to length in the field, and to have no heater-to-cold lead connections buried in the slab. Cover heater with a cross-linked fluoropolymer dielectric jacket and protect with a tinned-copper braid and a polyolefin, or fluoropolymer outer jacket.

D. Snow-melting Heating Cables: Provide electric heating cables which are suitable for embedment in asphalt and concrete paving material; of temperature, wattage and voltage ratings, Hz, BTUH's, and for the quantity and lengths indicated; terminate cable with 10' of factory-assembled non-heating leads and connectors. Construct cable of copper nickel alloy resistance wires spiraled on fiberglass core, with 0.043", or greater, layer of 105 deg. C polyvinyl chloride (PVC) insulation over spiraled wire. Provide sheath of 0.004", or greater, layer of nylon over PVC. Construct ground heater cable by encasing with 16 strands of #30 braided copper wire.

E. Pipe Freeze Protection Heating Cables: Provide self-regulating heat-tracing electric heating cable and components which are suitable for freeze protection of metal or plastic piping. Select heater consisting of 2-16 AWG tinned-copper bus wires parallel embedded in a radiation cross-linked conductive polymer core that varies its power output to respond to temperature along its length, allowing the heater to be crossed over itself without overheating, to be cut to length in the field, and to be used directly on plastic pipe. Cover heater with a radiation cross-linked modified polyolefin dielectric jacket. Provide heater with a self-regulating factor of greater than 90 percent to conserve energy and to prevent overheating. Self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heater output ranging from 40 deg. F (4 deg. C) pipe temperature operation to 150 deg. F (65 deg. C) pipe temperature operation.

F. Roof and Gutter De-icing Heating Systems: Provide self-regulating electric heating cable and components which are suitable for use on roofs and in gutters for snow and ice melting. Select heater consisting of 2-16 AWG tinned-copper bus wires embedded in parallel in a radiation cross-linked conductive polymer core that varies its heat output to respond to temperature along its length, allowing the heater to be crossed over itself without overheating, to be used safely in contact with wood, PVC, EDPM, neoprene and asphalt building materials, and to be cut to length in the field. Cover heater with a radiation cross-linked modified polyolefin dielectric jacket and protect with a tinned-copper braid and a polyolefin outer jacket. Provide self-regulating heater with a power output of 10 watts per foot where it contacts ice and snow and 5 watts per foot in air.

G. Hot-Water Temperature Maintenance Cable: Provide self-regulating electric heating cables which are suitable for wrapping pipes and fittings to compensate for heat loss along the hot-water supply piping and to maintain water temperature. Select cable with 2-16 AWG tinned-copper wires embedded parallel in a self-regulating polymer core that varies its power output to respond to temperature along its length, allowing the heater to be wrapped along the piping and to be crossed over itself, where necessary, without heating. Sheath the heater in a cross-linked fluoropolymer dielectric jacket and protect with outer jacket of tinned copper braid and polyolefin, or fluoropolymer. Provide hot-water temperature maintenance cable which can be cut to length in the field, and which possesses the following ratings and construction features:

System Temperature Rating: 120 deg. F (49 deg. C).
Supply Voltage: 208-volts.
Maximum Circuit Length: 575 feet.

H. Electric Heating System Controls: Provide electric radiant heating cable thermostats with temperature range from 35 to 95 deg. F (2 to 32 deg. C), operating voltage of 125, 60 Hz, and with manually operated OFF-position switch, as recommended by cable manufacturer.

I. Electric Heating System Controls: Electric heating cable temperature controls and snow detectors are specified in other Division 26 electric heating control sections.

J. Electric Heating System Accessories: Provide heating system accessories including, but not limited to, tapes, cable ties, warning labels, end seals and splices, and installation clips for the application indicated and for a complete system.

## PART 3 - EXECUTION

### 3.1 EXAMINATION:

A. Examine areas and conditions under which electric heating cables are to be installed and notify Contractor in writing of conditions detrimental to proper completion of the work. Ensure that surfaces, and pipes to which electric heating cables are to be installed are free of burrs and sharp protrusions and that pipes have been pressure tested for leakage. Also ensure that surfaces and substrates where cables are installed are plumb and level. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

### 3.2 INSTALLATION OF ELECTRIC HEATING CABLES:

A. Install electric heating cables including components as indicated, in accordance with equipment manufacturer's written instructions, applicable portions of NEC, and with recognized industry practices to ensure that units fulfill requirements. Comply with applicable installation requirements of NECA's "Standard of Installation".

B. Coordinate with other work including flooring, concrete, roofing, insulation, finish work, and electrical work as necessary to interface installation of electric heating cables with other work.

C. Protect installed electric heating cables, including leads, from damage and crushing by construction work.

D. Connect electrical power, fasten end-seals, and accomplish splicing of electric heating cables properly in accordance with requirements.

E. Tighten electrical connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A and B.

### 3.3 GROUNDING:

A. Provide equipment grounding connections for electric heating cables as indicated. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounding.

### 3.4 FIELD QUALITY CONTROL:

A. Prior to energizing electrical power circuitry, test installed electric heating cabling, including splice and tee connections, for electrical continuity.

B. After applying initial plaster, concrete coat, or thermal insulation, test cables for continuity and insulation resistance of 10 mega-ohms, or greater, measured to ground. Where leakage is detected, remove cabling and replace with new and proceed with retesting to demonstrate compliance.

C. After attaching electric heating cables to pipe, roof, or wire mesh, test cables for continuity and insulation resistance of 10 mega-ohms, or greater, measured to ground. Where leakage detected, remove cabling and replace with new and proceed with retesting to demonstrate compliance.

D. Subsequent to wire and cable installation, energize electric heating cables and demonstrate functioning in accordance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.

**END OF SECTION 23 83 13**

# DIVISION 26 ELECTRICAL

## 26 00 00 General Electrical Requirements

- Electrical Outages
  - Outages of any kind involving existing building systems will be scheduled in advance with the authorized Littleton Public Schools (LPS) Operations, Maintenance and Construction (OMC) and LPS Project Manager
  - Life safety systems must remain functional while a building is occupied.
    - Exceptions must be prearranged with and authorized by LPS OMC and LPS Project Manager.
- Temporary Wiring
  - Special safety considerations are required for temporary wiring installations in school buildings. All OSHA and NEC standards shall be met, as well as state and local building codes. The Contractor shall be responsible for any personal injury or property damage resulting from temporary wiring improperly installed or improperly protected.
- Existing Wiring
  - No additional loads will be attached to existing circuits except by permission of authorized LPS OMC and LPS Project Manager.
- Workmanship
  - Installation shall be performed in a neat and workmanlike manner and in accordance with all applicable local, State, and national code requirements. All installation shall be performed by licensed electricians and apprentices, who shall always be on- site while work of their trade is being performed, with licenses in their possession to be presented upon request as required by regulations.
- Sufficient electrical characteristics and capabilities shall be provided to support classroom and office computer installations.
  - A minimum of two dedicated 20amp circuits shall be provided to each classroom excluding computer rooms, which require special consideration.
- Final Acceptance and System Demonstration
  - All electrical equipment will be demonstrated as being fully functional. Installation, adds, changes, or modifications to new or existing fire alarm, temperature control, intercom, or any other control function-type systems shall be demonstrated to LPS OMC and LPS Project Manager as fully functional before final acceptance.
  - Cost of repairing to existing systems due to improper equipment or improper wiring shall be the responsibility of the Contractor.

### 26 05 00 Common Work Results for Electrical

- All material used on this project shall be UL listed and labeled and be acceptable to the Authority Having Jurisdiction (AHJ) as suitable for the use intended.
  - European and Canadian listings may also be acceptable to the AHJ.
- The contractor shall provide personnel with the ratio of Journeymen to Apprentices as mandated by the State of Colorado.

- All Journeymen shall be licensed, and all apprentices shall be registered with the State of Colorado electrical board.
  - Licenses and registration shall be produced upon request.
- When coring is required or identified, an x-ray of the area is to be taken prior to the performance of the work operation.
  - X-ray work requires a Method of Procedure (MOP) and protection.
- Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture
- Provide a complete product listing within four (4) weeks from award of contract to successful bidder.
- Contractor is responsible for sending removed lamps to be recycled. The Contractor should ensure the recycling agency meets RCRA and CERCLA regulations.
  - Provide certificate of compliance in O&M Manuals.

**26 05 05 Selective Demolition for Electrical**

- Personnel
  - Demolition required during construction shall be performed by qualified electrical personnel in such a manner as not to interrupt or destroy the integrity of existing systems.
- Reconnection
  - All systems that are disconnected due to construction needs, including phone, PA, security, or computer systems, shall be reconnected upon completion of the project. Exceptions must be authorized, in writing, by the LPS OMC and LPS Project Manager. The Contractor assumes the responsibility of reporting all system deficiencies, in writing, to LPS prior to commencement of work on the project. All systems will be considered fully functional and operational prior to project commencement unless properly reported as described here.
- Removal
  - All abandoned electrical conduit wiring, and devices shall be removed, and existing holes patched. Abandoned circuits and feeders shall be removed back to panels.
- Reinstallation
  - It shall be the responsibility of the Contractor to ensure proper installation and operation of existing electrical systems that may be affected by construction.
- Coordination
  - See also LPS Construction Standard 02 41 19 regarding coordination with LPS ITS Department for any work involving existing technology infrastructure in or around LPS facilities.

**26 05 19 Building Wiring, Electrical Power Conductors and Low-Voltage Cable**

- Work in this section is open to any product meeting the requirements of this Littleton Public Schools (LPS) Construction Standard.
- Section Includes

- Building wire
- Cable
- Wiring connections and terminations

- Coordination
  - Section 07 80 00 Fire and Smoke Protection
  - Section 26 05 53 Identification for Electrical Systems
  - Section 26 08 00 Commissioning of Electrical Systems
  - Division 23 – Low Voltage Systems
- In the absence of other information, the following standards apply:
  - NEMA WC 3 - Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
  - NEMA WC 5 - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- General Quality Control
  - Individual single pole breakers with handle ties shall be PROHIBITED.
  - Dedicated neutral for single phase to neutral loads only.
- Submittals
  - Required: Product Data Sheets
    - Also requires LPS OMC review and comment to design team
  - Closeout:
    - Submittals listed above updated to record status.
    - Operation and Maintenance Data
- Service entrance conductors:
  - Wire-rack conduit with State and NEC methods
- Building Wire
  - Install all building wire in raceway regardless of location
    - Armored Cable, MC Cable, ENT/NM, Modular Wire is PROHIBITED
      - Refer to 26 05 33 Raceway and Boxes for Electrical Systems for exceptions
  - Thermoplastic-Insulated Building Wire: NEMA WC 5.
  - Rubber-Insulated Building Wire: NEMA WC3.
  - Feeders and Branch Circuits 4 AWG to 250 kcmil: Copper, stranded conductor, 600-volt insulation, 75° C, THW, THHN/THWN, XHHW.
  - Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600-volt insulation, THW, THHN/THWN, XHHW. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, solid conductor.
  - Feeders and Branch Circuits 250 kcmil and Larger: Copper stranded conductor, 600-volt insulation, 75° C, THHN, XHHW, THW, THWN.

  - Control Circuits: Copper, #14 AWG, 19/25 stranding, THHN, 90° C, 600 volt. Multi- conductor control cables are allowed where more than three conductors are used between common terminations. Minimum of two spare control conductors in each cable.
  - Wiring: #12 AWG solid, minimum, with full size ground conductors unless specifically noted otherwise for certain limited applications.
  - 600-volt cross-linked polyethylene or thermoplastic insulated copper, 98% conductivity, single conductor.
  - Aluminum conductors are PROHIBITED in any application other than feeders furnished and installed by the power utility.
  - Direct buried cable is PROHIBITED

- Remote Control and signal cable
  - Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.
  - Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600-volt insulation, rated 75° C, individual conductors twisted together, shielded, and covered with interlocked aluminum armor.
  - Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 75° C, individual conductors twisted together shielded, and covered with a non-metallic jacket; UL listed and labeled as CL2, CL3, CL2R, CL3R, or PLTC.
  - Plenum Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300 volt insulation, rated 75° C, individual conductors twisted together, shielded, and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums and labeled as CL2P or CL3P.
- General Installation
  - VD% less than 3% total service to end use
  - Use no wire smaller than 12 AWG for power and lighting circuits and not smaller than 14 AWG for control wiring.
  - Use 10 AWG conductors for 20 ampere, 120-volt branch circuit home runs longer than 75 feet and for 20 ampere, 277-volt branch circuit home runs longer than 150 feet.
  - Make conductor lengths equal for parallel circuits.
- Wiring installation in raceways
  - Completely and thoroughly swab raceway system before installing conductors.
  - Pull all conductors into a raceway at the same time. Use UL-listed wire pulling lubricant rated for - 20ºF for pulling 4 AWG and larger wires.
  - Install wire only in complete raceways after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.
- Support cables above accessible ceilings at four to six-foot maximum intervals.

- Do not rest on ceiling tiles.
- Use hangar rods to support cables from structure.

- Wiring connections and terminations
  - Splice only in accessible junction or outlet boxes.
  - Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and larger.
  - Use insulated screw on type spring wire connectors with plastic caps for 10 AWG and smaller.
    - Push-on or stab-in wire nuts are PROHIBITED
  - Use copper compression connectors for copper wire splices and taps, 1/0 AWG and larger.
    - Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the conductor
  - Use U.L. listed connectors (Ilsco Clear Tap Products, or equal) for wire splices and taps, Ilsco Clear Tap or Burndy Hi Press #8-500 KCMIL
  - Tape or heat shrink uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of the conductor.
  - Terminate spare conductors with electrical tape.
  - Use only corrosion resistant connectors listed for terminations in wet locations.
- Field Quality Control
  - Control and signal cables passing through fire rated construction: In sleeves; conform to Construction Standard 07 80 00 Fire and Smoke Protection.
  - Provide sleeves for fire alarm, paging, data, telecommunications, and CATV.
- Wire and Cable Installation Schedule
  - Concealed Interior Locations: Building wire in raceways.
  - Exposed Interior Locations:  Building wire in raceways.
  - Above Accessible Ceilings:  Building wire in raceways.
  - Exterior Locations: Building wire in raceways.
  - Underground Locations: Building wire in raceways.
- Color Coding Schedule
  - Required for all wire sizes - full/length.
    - Factory applied
  - 208Y/120Volt Systems:
    - Phase A: Black
    - Phase B: Red
    - Phase C: Blue
    - Neutral: White
      - Colored stripe to indicate which phase it is connected to.

        - Ground: Green
    - 480Y/277 Volt Systems:
        - Phase A: Brown
        - Phase B: Orange
        - Phase C: Yellow
        - Neutral: Gray
            - Colored stripe to indicate which phase it is connected to.
        - Ground: Green
    - Low Voltage Systems:
        - Lighting Controls: No requirements

**26 05 26 Grounding and Bonding for Electrical Systems**

- Work in this section is open to any product meeting the requirements of this Construction Standard.
- Summary
    - Ground the main electrical service system according to the NEC.
    - Provide Concrete Encased Electrode (UFER).
- Section Includes
    - Power system grounding.
    - Communication system grounding.
    - Electrical equipment and raceway grounding and bonding.
- Submittals
    - Required: Shop Drawings
        - Indicate locations of system grounding electrode connections and routing of grounding electrode conductors
        - Also requires LPS OMC review and comment to design team
    - Closeout:
        - Submittals listed above updated to record status.
- Materials Summary
    - Ground Rods:
        - Copper-encased steel
        - 3/4-inch diameter
        - Minimum length 10 feet
- Execution Summary
    - Ground each separately derived system neutral as required i.e., steel structure.
    - The electrode should be terminated to XO before bonding to the transformer case.

- Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connections, potable cold-water supply, fire sprinkler main, and natural gas lines.
- All neutrals and grounds to comply with NEC via continuous conductor.

- Installation
  - Provide a separate, insulated equipment grounding conductor in all feeder and branch circuits. Feeders require steel ground bushing, all ends.
    - Terminate each end on a grounding lug, bus, or bushing.
    - Ground to all boxes unless otherwise specified
  - Use conduit grounding bushings on feeder circuits, flex conduits to transformers, services, and panels.
    - Motors:
      - Both ends all splice and pull boxes
      - Provide steel bonding bushings on feeders all ends, including motors, motor controls, disconnect for TVSS and VFD drives.
  - To establish the grounding electrical system, connect grounding electrode conductors to each of the following:
    - Metal potable cold water and fire sprinkler main pipe using a suitable ground clamp on the service side of the building shutoff valve per NEC.
      - Provide and label a bonding jumper around the water meter.
    - Steel structure where effectively grounded.
    - Concrete-encased electrode per NEC 250.52 (3).
  - Supplementary Grounding Electrode:
    - Use driven ground rods in main electrical room.
    - Install ground rod in suitable recessed well; fill with gravel after connection is made.
    - Use effectively grounded steel structure of the building.
  - Use minimum 4 AWG copper conductor for communications service grounding conductor.
    - Insulated from building
    - Terminate to approved grounding bus.
  - All conduit and raceways shall contain an insulated ground wire sized per NEC 250.122
  - Provide grounding and bonding at utility company's metering equipment and in accordance with utility company's requirements.

**26 05 29 Hangers and Supports for Electrical Systems**

- Work in this section is open to any product meeting the requirements of this Construction Standard.

- Section Includes
  - Conduit and equipment support.
  - Fastening hardware.
- Coordination
  - Division 03 – Concrete, for electrical equipment pads
- Submittals
  - Required: Product Data Sheets
    - Also requires LPS OMC review and comment to design team
  - Required: Shop Drawings
    - Also requires LPS OMC review and comment to design team
  - Closeout:
    - Submittals listed above updated to record status.
- Support Channel:
  - Galvanized or painted steel.
- Conduit Supports
  - Clamps, straps, supports:
    - Steel or malleable iron
  - Galvanized straps, lay-in adjustable hangers, clevis hangers or bolted split stamped galvanized hangers
  - Perforated pipe strap is PROHIBITED.
  - Wire is RESTRICTED
    - Only allowed when used for one (1) single 1” or less conduit, MC Cable, and associated junction box
  - Arrange to prevent distortion or misalignment from wire pulling.
  - Spacing:
    - Per NEC
    - In no case more than 2' from panels, boxes, conduit bodies
    - 8 feet-0 inches o.c.
  - All rooftop-installed raceways:
    - Shall be steel and be properly supported by Unistrut-type roof stands
    - Approved manufacturer(s)
      - Miro Industries
        - Miro Industries electrical conduit supports Model Numbers CS-4-RAH-HDG or CS-6-RAH-HDG (hot dipped galvanized), size as required for electrical conduit on roof. All electrical conduits are to be clamped per NEC requirements.

        - Furnish and install Miro Industries Pillow Block Pipe Stands Model 1.5 with 1.5 Spacer (for electrical conduits 3" or less above finished roof height).
      - B-Line
        - Equivalent products
    - Approved equivalent
    - Coordinate with Division 07
      - Membrane penetration details
      - Stands shall have slip sheets approved for roof membrane type.
    - All such fabrications shall be submitted for LPS OMC review.
- Fabricate supports from structural steel or steel channel, rigidly welded, or bolted to present a neat appearance.
  - Hardware: Corrosion resistant.
- Secure transformers and switchgear to floor or slab. Install approved vibration isolators on transformer mounting hardware.
  - Under distribution switchboards, install free-standing electrical equipment on 4-inch concrete pads.
- Install surface-mounted cabinets, panelboards, and transformers with minimum of four anchors.
  - Align tops of all adjacent cabinets.
- Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.
- Fasteners
  - Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors or preset inserts.
  - Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls.
  - Use expansion anchors or preset inserts in solid masonry walls
  - Use self-drilling anchors or expansion anchor on concrete surfaces
  - Use sheet metal screws in sheet metal studs.
  - Use hexagon head bolts with spring lock washers under all nuts.
  - Powder-actuated anchors are PROHIBITED without specific written permission.
- Quality Control
  - Fasten supports directly to structure.
  - Do not fasten supports to piping, ductwork, mechanical equipment, conduit, or ceiling system suspension wires or wire of any type.
  - Drilling or other modification of structural steel members is PROHIBITED without specific written permission from the structural engineer.

## 26 05 33 Raceway and Boxes for Electrical Systems

- General
  - Existing building piping shall not be used except by specific permission of LPS OMC and LPS Project Manager.
  - New conduit and cabling shall be aligned parallel and perpendicular to building structure and shall be concealed except in equipment rooms or approval of LPS OMC and LPS Project Manager.
  - Conductors of 50 volts or more shall be installed in approved raceways. Cabling of less than 50 volts when not installed in approved raceways shall be plenum rated.
  - Electrical conduit shall be properly reamed to prevent damage to wire insulation.
  - Plumbing-type pipe cutters shall not be used on electrical conduit except when used for cutting ridged pipe (GRC) and proper care is taken not to reduce internal diameter.
  - Boxes in walls shall be securely fastened in such a manner as not to rely on cover trim plate for support.
  - Penetrations shall be made in such a way as to maintain structural integrity and firewall rating. Non-firewalls will be patched as required to prevent environmental air from passing from one zone to another.
    - All penetrations will be sealed with expanding foam to prevent airflow by 98 percent minimum or as required by standards of Underwriters Laboratories Fire Resistance Directory, current edition, or applicable Code or AHJs. Roofs and outside walls will be properly sealed to prevent leakage.
    - All penetrations through any wall, floor or roof for any reason shall be sleeved and fire caulked. See requirement of Section 07 80 00.
- Coordination
  - Section 08 31 00 Access Doors and Panels.
  - Section 26 05 53 Identification for Electrical Systems.
  - Section 26 27 16 Electrical Cabinets and Enclosures.
  - Section 26 27 26 Wiring Devices: Service fittings and fire-rated poke-through fittings for floor boxes.
  - Trenching: Division 31
  - Roof penetrations are PROHIBITED unless coordinated and detailed in strict compliance with Division 07.
  - Coordinate exposed and surface mounted runs with Architect prior to rough-in.
- In the absence of other information, the following standards apply:
  - ANSI/EMA OS 1 Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
  - NEMA 250 Enclosures for Electrical Equipment (1000 volts maximum).
  - ANSI C80.1 Rigid Steel Conduit, Zinc Coated
  - ANSI C80.3 Electrical Metallic Tubing, Zinc Coated

- ANSI/NEMA FB 1 Fittings and Supports for Conduit and Cable Assemblies
- NEMA RN 1 PVC Externally Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing
- NEMA TC 2 and TC 3 PVC Fittings for Use with Rigid PVC Conduit and Tubing

- Applications
  - Acceptable under-slab-on-grade installation (within buildings):
    - Main and branch lines
    - Homeruns from branch circuits
  - Underground installations more than 5 feet from foundation wall:
    - Rigid Metal Conduit
    - Intermediate Metal Conduit
    - Plastic coated Rigid steel conduit
    - Schedule 40 PVC conduit, with 90-degree plastic coated rigid steel conduit where it protrudes out of the earth.
  - Underground installations within 5 feet of foundation wall or in or under concrete slab:
    - Rigid Metal Conduit
      - Transition between PVC and metal conduit below grade must use Composite 90's ONLY when making a transition above grade
    - Intermediate Metal Conduit
    - Plastic coated rigid steel conduit
      - Schedule 40 PVC conduit, with 90-degree composite transitions to coated rigid steel conduit 1 foot (12") below and 4" minimum where it protrudes out of the earth.
  - Exposed outdoor locations
    - Rigid Metal Conduit (GRC) 0-4'
    - Intermediate Metal Conduit 0-4'
    - Electrical Metallic Tubing 4'- +
  - Wet interior locations
    - Rigid Metal Conduit 0-4'
    - Intermediate Metal Conduit 0-4'
    - Electrical Metallic Tubing 4'- +
  - Concealed dry interior locations
    - Rigid Metal Conduit
    - Intermediate Metal Conduit
    - Electrical Metallic Tubing
  - Exposed dry interior locations

        - Rigid Metal Conduit (GRC) 0-4'
        - Intermediate Metal Conduit 0-4'
        - Electrical Metallic Tubing 4'- + (AFF and AFG) Applies to all.
- Restrictions
    - Attachment of conduit and tubing to any exterior part of the building envelope is PROHIBITED without the approval of LPS OMC, LPS Project Manager and compliance with Division 07 of these Construction Standards.
    - Horizontal conduit runs within above grade concrete slabs are PROHIBITED.
- Submittals
    - Product Data: Required for surface raceways, multi-outlet assemblies, auxiliary gutters, and accessories.
        - Also requires LPS OMC review and comment to design team
    - Shop Drawing: Required
        - Also requires LPS OMC review and comment to design team
    - Closeout: Submittals listed above, updated to record status.
- Wall and ceiling outlet boxes
    - Open to any product meeting the requirements of this Construction Standard.
    - Sheet Metal Outlet Boxes:
        - ANSI/NEMA OS 1.
        - Galvanized steel, with 1/2-inch male fixture studs where required.
        - Standard size for all systems: 4 inches x 4 inches x 2 1/8-inch minimum depth
    - Cast Boxes:
        - Aluminum, deep type, gasketed cover, threaded hubs.
- Pull and Junction Boxes
    - Standard size for all systems: 4 inches x 4 inches x 2 1/8-inch minimum depth
        - Shallow boxes are PROHIBITED
        - Single gang boxes are PROHIBITED
    - All junction boxes in high ceiling areas shall be accessible from lift.
    - RESTRICTED to specific manufacturers that have been previously approved by LPS.
        - Appleton Electric
        - Bowers
        - Carlton
        - Lew Electric
        - National Electrical Products
        - Raco

        - Steel City
- Sheet Metal Boxes less than 24 inches: ANSI/NEMA OS 1; galvanized steel.
    - Sheet Metal Boxes Larger than 24 inches in any dimension: Hinged enclosure in accordance with Section 26 27 16.
    - Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as rain tight. Cast aluminum box and cover with ground flange, neoprene gasket and stainless-steel cover screws.
        - PROHIBITED in vehicle traffic areas
    - Fiberglass Handholes for Underground Installations:
        - Die-molded with pre-cut 6 x 6-inch cable entrance at center bottom of each side
        - Fiberglass weatherproof cover with non-skid finish
        - Traffic Rated
        - 20k rated weight minimum.
        - PROHIBITED in vehicle traffic areas such as parking lots and drives.
    - Locate and install boxes above accessible ceilings or in unfinished areas to allow access.
        - Where installation is inaccessible, coordinate locations and size of required access doors.
        - In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed luminaire, to be accessible through luminaire ceiling opening.
    - Locate and install boxes to maintain headroom and to present a neat appearance.
    - Support pull and junction boxes independent of conduit.
- Floor Boxes
    - The use of floor boxes is RESTRICTED.
        - Consider other options first.
        - Coordinate with LPS OMC.
    - RESTRICTED to specific manufacturers that have been previously approved by LPS.
        - Appleton Electric
        - Bowers
        - Hubbell
        - Lew Electric
        - Raceway Components Inc.
        - Rotco Inc.
        - Steel City

        - Walker
        - Wiremold
- Outlet Boxes
    - Open to any product meeting the requirements of this Construction Standard.
    - Do not install boxes back-to-back in walls.
        - Provide minimum 6-inch separation.
        - 24-inch separation in acoustic or fire-rated walls.
    - Locate boxes in masonry walls to require cutting of masonry unit corner only.
    - Provide knockout closures for unused openings.
    - Support boxes independently of conduit except for cast boxes that are connected to two rigid metal conduits, both supported within 12 inches of box.
    - Use multiple-gang boxes where more than one device is mounted together
        - Sectional boxes are PROHIBITED.
    - Provide barriers to separate wiring of different voltage systems.
    - Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioning to allow for surface finish thickness.
        - Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.
    - Provide cast outlet boxes in exterior locations exposed to the weather and wet interior locations.
    - Exposed boxes in kitchens and shops:
        - Provide bell type boxes with threaded openings.
- Underground Pull Boxes in vehicle traffic areas is PROHIBITED.
- Underground Ducts and Raceways
    - Buried Raceways: PVC Coated rigid steel galvanized conduit or Schedule 40 or 80 rigid PVC plastic conduit.
    - All fittings shall be composite, all other types are PROHIBITED
    - All conduits installed underground shall be buried a minimum of 18" below finished grade including sidewalks.
- Rigid Metal Conduit and Fittings
    - Work in this section is open to any product meeting the requirements of this Construction Standard.
    - Rigid Steel Conduit:
        - ANSI C80.1 galvanized
    - PVC Externally Coated Conduit:
        - NEMA RN 1 Rigid steel conduit with external 40 mil PVC coating and internal galvanized surface
    - Fittings and Conduit Bodies:

        - ANSI/NEMA FFB 1
        - Threaded type, material to match conduit
- Intermediate Metal Conduit and Fittings
    - Open to any product meeting the requirements of this Construction Standard.
    - Conduit:
        - Galvanized steel
    - Fittings and Conduit Bodies: ANSI/NEMA FB 1; Threaded type, material to match conduit
- Electrical Metallic Tubing and Fittings
    - Open to any product meeting the requirements of this Construction Standard.
    - EMT:
        - ANSI C80.3 Galvanized tubing
    - Fittings:
        - ANSI/NEMA FB 1
        - High quality, insulated throat, steel set screw
        - Die cast fittings are PROHIBITED
    - Steel Compression Fittings:
        - High quality compression is required on surface work in kitchens, greenhouses, and other areas where waterproof fittings are required by NEC
    - Conduit Bodies: Aluminum, steel, or malleable iron
        - PVC is PROHIBITED
    - Flexible Metal Conduit and Fittings, ½" and larger
        - Open to any product meeting the requirements of this Construction Standard.
    - Use only at fixture whips and part of a listed assembly.
        - All other locations PROHIBITED.
    - Conduit:
        - Steel
    - Fittings and Conduit Bodies:
        - ANSI/NEMA FB 1
        - Material to match conduit
    - Length:
        - 6 feet maximum except where fished or approved by NEC and LPS OMC.
- Liquid Tight Flexible Metal Conduit and Fittings
    - Open to any product meeting the requirements of this Construction Standard.
    - Conduit:
        - Flexible metal conduit with PVC jacket

- Fittings and Conduit Bodies: ANSI/NEMA FFB 1; waterproof material to match conduit.
- 6 feet maximum lengths or as required by NEC.

- Non-Metallic Conduit and Fittings
  - Above grade use is PROHIBITED.
  - Transition between PVC and metal conduit below grade.
    - Must use Composite 90's to transition above grade.
      - PVC Coated rigid conduit shall extend a minimum 1 foot (12") below grade and a minimum of 4" above grade.
  - Open to any product meeting the requirements of this Construction Standard.
  - Conduit:
    - NEMA TC 2; Schedule 40 PVC
  - Fittings and Conduit Bodies: NEMA TC 3
  - PROHIBITED for exposed or concealed applications in stud and masonry walls or ceiling plenum.
  - Wipe plastic conduit clean and dry before joining
  - Apply full even coat of cement to entire area that will be inserted into the fitting
  - Cure joint 20 minutes minimum
  - PVC expansion couplings shall be used at transition between grade and building surface, and as required by NEC.
- Plastic surface raceways PROHIBITED.
- Surface Metal Raceways
  - RESTRICTED to EMT or GRC.
  - RESTRICTED to Renovation or Remodel work where interior walls are not accessible
  - PROHIBITED in new work
  - Use insulating bushings and inserts at connections to outlets and corner fittings
  - Maintain grounding continuity between raceway components
  - Preferred location: below work surfaces or deck tops
- Auxiliary Gutters
  - Open to any product meeting the requirements of this Construction Standard.
  - General purpose type wireway, with knockout
  - Connector:
    - Hinged cover
      - Screw applied cover.
  - Lay-in type fittings with removable top, bottom, and side, captive screws.
  - Rust inhibiting primer coat with gray enamel finish.

- Bolt auxiliary gutter to steel channels fastened to the wall or in self-supporting structure.
- Install level
- Gasket each joint in oil-tight gutter.
- Mount rain tight gutter in horizontal position only.

- Accessories
  - Open to any product meeting the requirements of this Construction Standard.
  - Conduit Rack:
    - Steel channel with conduit straps or clamps.
    - Oversize by 30%
- Conduit Size
  - Size conduit for installed conductor type or for type THW conductors, whichever is larger.
  - Home runs to switchboards and panels: 3/4 inch minimum
  - 3/4 inch for all runs
  - Conduits used for home runs shall contain only the conductors for the circuits indicated on the drawings.
- General Installation Requirements
  - All surface mount conduits in exposed areas shall be 1 hole strapped to surface (example no mineralac pipe supports).
  - Conceal conduit to the greatest extent possible
  - Run conduit parallel and perpendicular to adjacent walls, ceilings, piping, exposed and concealed.
  - Install horizontal runs of conduit to maintain a minimum clearance of 6 inches above ceiling grid assembly where possible.
  - Maintain 6-inch minimum clearance between conduit and piping.
  - Maintain 12-inch minimum clearance between conduit and heat sources such as flues, pipes, and heating appliances.
  - Group conduit in parallel runs where practical.
    - Where 2 or more conduits run in parallel a trapeze or Unistrut rack shall be used
    - Conduit Rack is preferred.
  - Remove temporary conduit supports before pulling conductors
  - Exposed/concealed interior locations
    - Raceway, cables, boxes installed under metal-corrugated sheet roof decking shall be installed and supported to maintain a minimum of 3- inch clearance from the lowest surface of the roof decking to the top of the raceway, cable, or box.
- Special Installation Techniques

- Bring conduit to the shoulder of fittings and couplings.
- Fasten securely
- In damp or wet locations, use conduit hubs or sealing locknuts for fastening conduit to cast boxes and to fasten conduit to sheet metal boxes.
- Use conduit bodies to make sharp changes in direction, as around beams
- Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2-inch size
- Avoid moisture traps. Where unavoidable, provide junction box with drain fitting at conduit low point
- Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture
- Use nylon pull string ("jetline") with a pull strength of 200 pounds or greater in empty conduits except sleeves and nipples.
- Use PVC coated rigid steel factory elbows
  - For bends in plastic conduit runs longer than 100 feet
  - In plastic conduit runs which have more than 2 bends, regardless of length

- Interface with other work
  - Install expansion joints, both sides, where raceway crosses:
    - Foundation wall below grade.
    - Building expansion joints.
  - Where conduit penetrates fire rated construction, provide pipe sleeves 2 sizes larger than conduit.
  - Coordinate with Section 07 80 00 Fire and Smoke Protection.
- Interior and Exterior underground and Concrete Encased Conduit
  - Interior and exterior slab-on-grade: Install conduit 6 inches minimum below bottom of slab-on-grade to top of conduit unless otherwise authorized by LPS OMC.
    - Properly prepare trench bedding
    - Follow main corridors to the greatest extent possible
  - Minimum slope: 4%
  - Minimum size: 3/4 inch
  - Use suitable separators and chairs installed no more than 4 feet 0 inches o.c. and securely anchor conduit to prevent movement during placement of concrete
  - Provide minimum 3-inch concrete cover at top, bottom, and sides of conduit.
  - Seal ends to be completely water tight.
  - Install warning ribbon in trench 12 inches above raceway or cable.
- Raceway for telephone, television, paging, and local area network.
  - Conduit runs less than 100 feet from point-to-point shall not contain more than two 90º standard factory bends, or three 90º , 24-inch radius bends.

- Conduit runs exceeding 100 feet from point-to-point or exceeding two 90º - 24" radius bends shall contain accessible pull boxes.

**26 05 36 Cable Tray Raceways**

- RESTRICTED to specific manufacturers that have been previously approved by LPS:
  - B-Line Systems
  - Globe
  - Husky-Burndy

**26 05 53 Identification for Electrical Systems**

- Work in this section is open to any product meeting the requirements of this Construction Standard.
- Contractor ADVERTISING of any kind is PROHIBITED
- Panel boards, switch gear, and motor control centers shall have permanent, engraved plastic nameplates clearly designating equipment or panel and will include a complete typewritten list identifying circuit use and location.
  - When circuits are added to existing panels, new circuits shall be clearly identified. Junction boxes shall be identified with panel and circuit number.
  - Concealed or mechanical room junction boxes shall be labeled on outside of cover; exposed junction boxes shall be labeled on inside of cover.
  - All device cover plates shall be labeled with panel and circuit numbers.
- Framed graphic map of one line diagram of the electrical system, mounted in the main electrical room. These shall be extracted from the close out documents. Include room numbers for all electrical panel locations and arc flash calculations on one line.
  - Also included when any changes are made to MDC or SDC and updates are necessary.
  - One-line diagrams shall be installed in a protective cover and frame at each location.
- Nameplates, wire markers, or labels are required at each component of the electrical system.
- Coordinate with Section 09 90 00 Painting and Coating
- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Shop Drawing: required
    - Also requires LPS OMC review and comment to design team
    - Include complete schedule of nameplates and labels.
  - Samples: required
  - Closeout:

        - Submittals listed above
        - Updated to record status.
        - Samples excluded
- Color Code – Printed Self-Adhesive Labels:
    - Black characters on white or clear background for "Normal",
    - White characters on red background for "Emergency" and fire alarm devices
    - White characters on green background for "Ground".
- Nameplates:
    - Mechanically mounted - riveted.
    - White letters on black background.
    - Provide engraved nylon trim plates for gym lighting corridor and boxes three (3) gang and larger.
    - Provide on all large equipment
    - Distribution and control equipment
        - Engraved three-layer laminated plastic
        - UV Resistant
    - Identify equipment and loads served.
        - 1/8-inch lettering for individual switches and loads served
        - 1/4-inch lettering for distribution and control equipment.
    - Panelboards and Switchboards:
        - 1/4-inch lettering to identify equipment designation
        - 1/8-inch lettering to identify voltage rating and source.
    - Individual Circuit Breakers and Switches in Panelboards and Switchboards:
        - 1/8-inch lettering to identify circuit and load served, including location.
    - Individual Circuit Breakers, Enclosed Disconnect Switches, and Motor Starters:
        - 1/8-inch lettering to identify load served and circuit designation.
    - Transformers:
        - 1/4-inch lettering to identify equipment designation.
        - 1/8-inch lettering to identify primary and secondary voltages, primary source, and secondary load and location.
    - Main Grounds:
        - 1/4-inch lettering "Do Not Disconnect". 1/4-inch lettering to identify type of ground.
- Printed, Laminated Labels:
    - Self-adhesive, thermal transfer tape
    - Minimum 3/8-inch-high characters

- Colors as noted in color code above
- Use only for identification of individual wall switches and receptacles, control device stations.
- Locate tape on the front side of the cover plate and with indelible ink on the back of the cover plate and with indelible ink on the device/junction box.
- Electrical Disconnects above ceilings and other semi-concealed spaces.

- Wire and Cable Markers:
  - Permanently printed split sleeve tube type adhesive backed circumferential:
  - Brady, or approved equivalent.
- Degrease and clean surfaces to receive nameplates and tape labels.
- Install nameplates and tape labels parallel to equipment lines.
  - Secure nameplates to equipment fronts using screws, rivets.
  - Secure nameplate to inside face of recessed panelboard doors in finished locations.
- Label “Grounding Electrode Conductor” and “Main Bonding Jumper” with engraved tags.
- Wire Identification
  - Provide wire markers on each conductor in panelboard gutters, pull boxes, outlet, and junction boxes, and at load connection.
  - Identify with branch circuit or feeder number as indicated on equipment manufacturer’s shop drawings for control wiring.
- Junction Box and Pull Box Identification
  - Use indelible black marker to inscribe circuit or bus, switch numbers and source panel on the outside of each junction and pull box cover.
- Systems Identification
  - Arc flash labeling on all equipment including disconnects. Per NFPA 70E
  - Telephone:
    - Identify telephone raceways with the label “TELEPHONE” on pull and junction boxes and conduit at the termination points.
    - Identify Telephone Termination Backboard with the legend “TELEPHONE” on pull and junction boxes and conduit at the termination points.
  - Television:
    - Identify television raceways with the label “TELEVISION” on pull and junction boxes and conduit at the termination points.
  - Label outlets and switches in front with printed labels, back of plate use indelible ink.

**26 05 83 Wire Connectors**

- RESTRICTED to specific types by LPS to:

- Splitbolt, Setscrew, Compression, Wingnut, Wirenut

- PROHIBITED CONNECTORS:
  - Push, Quick, Stab Lock and/or equivalent

**26 08 00 Commissioning of Electrical Systems**

- Work in this section is open to any product meeting the requirements of this Construction Standard.
- Testing is required for all Division 26 equipment, wiring, devices, etc. to assure that electrical equipment is operational within industry and manufacturer's tolerances and conforms to the contract documents.
- In the absence of other information, standards of the following organizations apply:
  - National Electrical Testing Association, Inc. - NETA.
  - Association of Edison Illuminating Companies - AEIC.
- Submittals
  - Documentation of Testing Agency accreditation: required
  - Written Test Reports: required
    - Preliminary
    - Certified Final Test Reports
  - Electronic copies to LPS OMC of all testing and procedures.
  - Closeout:
    - Submittals listed above updated to record status.
- Testing Equipment
  - All instruments used to evaluate electrical performance shall meet NETA's Specifications for Test Instruments.
    - The Contractor shall have a calibration program which maintains each applicable test instrument within its rated accuracy.
  - Instruments shall be calibrated in accordance with the following frequency schedule:
    - Field instruments - 6 months maximum.
    - Laboratory instruments - 12 months.
    - Leased specialty equipment - 12 months.
  - Dated calibration labels shall be visible on all test equipment.
  - Maintain an up-to-date instrument calibration instruction for each test instrument.
  - Maintain up-to-date documentation showing date and results of instrument calibration and testing.
- Acceptable Testers
  - Any independent testing laboratory meeting federal OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907. Membership in the National Electrical Testing Association constitutes proof of meeting such criteria.
  - Electrical subcontractor unless otherwise noted.

- Testing Schedule
  - Cables - Low Voltage (600 Volts and less – Electrical Systems Only)
    - Visual and Mechanical Inspection
      - Inspect cables for physical damage and proper connection in accordance with the engineer's single line diagram.
      - Torque test each feeder cable connection to the manufacturer's recommended value.
      - Branch circuits excluded.
    - Electrical Tests
      - Prior to final wire termination perform an insulation resistance test on each feeder cable (branch circuit wires are excluded) with respect to ground and adjacent cables.
      - Perform continuity test to insure proper cable connection.
      - Test Values:
        - Insulation resistance tests shall be performed at 1000 volts D.C. for 30 seconds.
        - Minimum resistance value: 250,000 ohms.
  - Circuit breakers - low voltage
    - Visual and Mechanical Inspection
      - Check each circuit breaker for proper mounting, conductor size and feeder designation.
      - Operate each circuit breaker to insure smooth operation.
      - Inspect each case for cracks or other defects.
      - Check tightness of each connection with torque wrench in accordance with manufacturer's recommendations.
  - Grounding Systems
    - By independent testing laboratory only
    - Visual and Mechanical Inspection
      - Inspect ground system for compliance with plans and specifications.
    - Electrical Tests:
      - Test before any work has started and at completion. Contractor guarantees that grounding is compliant if no test has been completed prior to work.
      - Perform fall of potential test per IEEE Standard No. 81, Section 9.04, on the main grounding electrode or system.
      - Perform the two-point method test per IEEE No. 81, Section 9.03 to determine the ground resistance between the MDCs and SDPs.
      - Test Values:

- The main ground electrode system resistance to ground should be no greater than 5 ohms.

- Ground Fault Systems (NEC 230-95)
  - By independent testing laboratory only
  - Visual and Mechanical Inspection:
    - Inspect for physical damage and compliance with plans and specifications.
    - Inspect neutral main bonding connection to assure:
      - Zero sequence system is grounded upstream of sensor.
      - Ground strap systems are grounded through sensing device.
      - Ground connection is made ahead of neutral disconnect link.
    - Inspect control power transformer to insure adequate capacity for system.
    - Manually operate monitor panels (if present) for:
      - Trip test.
      - No trip tests.
      - Non-automatic reset.
    - Record the proper operation and test sequence.
      - Provide written results to LPS OMC and LPS Project Manager
    - Inspect zero sequence systems for symmetrical alignment of core balance transformers about all current carrying conductors.
    - Verify ground fault device circuit nameplate identification by device operation.
    - Set pickup and time delay values in accordance with the engineer's design on construction documents.
    - Set main switch GFI to job-specific values.
    - Do not leave at factory minimum setting.
  - GFI Settings shall be verified by independent testing.
    - Print GFCI relay settings on electrical one-line drawing.
- Electrical Test: By independent testing laboratory only.
  - Infrared test of all electrical switchgear, lugs, power, and light panels under full load.
  - Infrared test at 11month walk, of all electrical switchgear, lugs, power, and light panels under full load.
  - Remove the neutral-to-ground connecting link to measure the neutral insulation resistance and ensure that no shunt ground paths exist. Replace the link.
  - Determine the relay pickup current.
  - Test system operation at 125% rated voltage.
  - Test Parameters:
    - System neutral insulation shall be a minimum of one megohm or greater.

- Relay pickup current: Within 10% of device dial or fixed setting and in no case greater than twelve hundred amperes.
- Relay timing: In accordance with manufacturer's published time current characteristic curves but in no case longer than one second.

- Provide written results to LPS OMC and LPS Project Manager.
- Submit written results with Close-out Documents.

- See Division 27 for testing requirements of communication and alarm systems.

## 26 09 00 Instrumentation and Control for Electrical Systems

### 26 09 33 Lighting Controls

- General Guidelines
  - Review lighting control design options during schematic design development with LPS OMC Electricians and LPS PM for approval.
  - Comply with latest state adopted IECC standard.
  - Comply with Illuminating Engineering Society for educational spaces
  - Provide control systems which are local to spaces and non-centralized.
  - The lighting control system shall “sweep off” all controlled interior lights that are not controlled with an occupancy sensor at pre-determined programmable intervals during unoccupied times.
    - Occupancy sensors in occupied spaces shall be programmed to stay on for ten minutes after last detecting motion or sound.
    - Occupancy sensors in spaces normally unoccupied shall be programmed to stay on for five minutes.
  - Occupancy sensors shall be installed per manufacturer recommendations. Provide dual technology occupancy sensors (infrared and passive sonic) with auto-on-off capability. Occupancy sensor(s) shall turn off all lights in the room after a pre-set but programmable interval after room has been vacated (default 1-hour). Lighting control equipment shall be locked, located, or otherwise made secure against vandalism.
  - Keyed switches or lockable covers required in auditoria, gymnasiums, cafeterias, corridors, locker rooms, and student restrooms.
  - Upon failure of normal power, emergency lighting fixtures shall automatically operate from the emergency power source. Emergency lights shall turn-on in case of power failure. Upon return of normal power all emergency fixtures shall return to their prior state.
  - Interior photosensors for daylighting control shall be located and wired per manufacturer recommendations. The Designer is required to coordinate with the manufacturer to determine the best location for the sensors and the most appropriate wiring approach, which could be open or close loop.
  - Demolish unused branch circuiting and conduit back to the panel. Label unused breakers as “SPARE” in Contract Drawings.
- Specific Control Requirements

- Illuminances are provided for each space type per the Illuminating Engineering Society.
- The lighting control system shall include but not be limited to the following areas:
  - Classroom Lighting Controls (also Laboratories and CTE)
    - All classrooms shall utilize a local room controller to support control configuration functions and devices as listed within this section. Room controller(s) shall support the desired presets in addition to being equipped with manual dimming of all room luminaires
    - The room controller shall be UL924 listed where used in conjunction with an emergency power source for emergency lighting.
    - Each classroom shall be equipped with a controller with eight preset buttons as outlined in 26 50 00. Lighting Designer/Electrical Engineer shall verify that illuminance presets provide the levels listed in LPS Construction Standard Section 26 50 00.
    - Provide single zone lighting controls for each classroom.
    - Provide dual technology occupancy sensors with auto-on-off capability. Occupancy sensor(s) shall turn off all lights in the room 10 minutes after room has been vacated.
    - If required, provide photo sensor(s) with necessary interconnections to the classroom lighting dimming controls. Amperage changes in light fixtures shall be proportional to external light changes. In addition to manual dimming, the fixtures shall automatically dim at a rate slow enough to not be bothersome to occupants. Locate photo sensors in an optimal place for the lights to be controlled. Photo sensors shall not be positioned where the device will be affected by direct sun light, room luminaires or obstructions. Local control station shall override daylight harvesting functions.
    - Circadian rhythm lighting shall, be equipped with eight presets defining color temperature and illuminance as well as a full range dimmer to allow manual adjustment of color temperatures and melanopic content. The keypad shall be fully capable of tuning between preset CCT as well as controlling the light level in the space.
    - The use of touchscreens is PROHIBITED unless approved by LPS OMC and LPS Project Manager.
    - The use of wireless controls is PROHIBITED in new buildings. The use of wireless controls existing buildings is PROHIBITED unless approved by LPS OMC and LPS Project Manager.
- Offices, Workrooms, and Conference Rooms
  - Each space shall be equipped with a manual dimmer.
  - Dual Technology Occupancy sensors shall be configured as “vacancy” sensors or as manual on/auto off. Luminaires shall remain lit for 5 minutes after last detecting motion.
- Locker Rooms.

- Provide ceiling-mounted occupancy sensor(s) as required for full coverage. Occupancy sensors shall turn off all lights in the room via a pre-set but programmable interval after the room is vacated. At minimum, occupancy sensor to be placed to detect motion upon entering the space.

o Gymnasium

- Wall-mounted dimmer switches shall provide for manual light reduction when daylighting is adequate, or for darkening of the room for activities. Locate dimmer switch easily accessible to the teacher.
- Provide dual technology occupancy sensors (infrared and passive sonic) with auto-on-off capability. Occupancy sensor(s) shall turn off all lights in the room after a pre-set but programmable interval after room has been vacated.
- If required, provide photo sensor(s) with necessary interconnections to the classroom lighting dimming controls. Amperage changes in light fixtures shall be proportional to external light changes. In addition to manual dimming, the fixtures shall automatically dim at a rate that is slow enough to not disrupt occupants. Locate photo sensors in an optimal place for the lights to be controlled. Photo sensors shall not be positioned where the device will be affected by direct sun light, room luminaires or obstructions. Local control station shall override daylight harvesting functions.
- If multi-level switching is present keep circuiting in place and add dimming capability.
- Middle and High School gyms shall be capable of providing 50% illuminance. This may be achieved through dimming or selective switching. The most practical approach shall be determined by the Lighting Designer/Electrical Engineer.
- If a curtain divider is present, provide separate switching for both sides.

o Auditoria

- Provide preset controller and dimmer for control of general lighting.
- Provide means of control of house lights from backstage and from control booth. Lighting controls accessible in the space shall be equipped with a lockable cover.
- If this or any other area or room is intended for general assembly and utilized in a manner that requires dimming or turning off the lighting, the house lighting shall be interfaced with the Fire Alarm System, which in case of a fire emergency will force the lighting fully on regardless of the manual or automatic control settings.

o Cafeteria

- Provide ceiling mounted occupancy sensor(s) with switch(es) with four presets and manual dimming. Quantity and placement of occupancy sensors shall allow detection of persons located throughout the room.

o Staff Restrooms

- Occupancy sensor switches adjacent to the door, and wall mounted occupancy sensors for on/off controls. The sensor shall be configured in a “vacancy” or Manual On / Automatic Off configuration.

- If the exhaust fan is dedicated to the restroom or a pair of ganged restrooms, luminaire and exhaust fan operation shall be interlocked.

o Student's Restrooms

- Occupancy sensor switches adjacent to the door, and ceiling mounted occupancy sensors for on/off controls. The sensor shall turn off the lights after the room has been vacated.
- If the exhaust fan is dedicated to the restroom or a pair of ganged restrooms, lights and exhaust fans shall be interlocked.

o Main Office

- Provide non-locking local switching for manual operation. In addition, use light sensor(s) to reduce electric lighting levels in areas where natural lighting contribution is significant.
- Individual offices to be equipped with wall mounted occupancy sensor switches in the "vacancy" or Manual On / Automatic Off configuration.
- Central building lighting controls for common areas shall be located here and in the Facilitator's office.

o Conference rooms

- Provide non-locking local switching for manual operation. In addition, use light sensor(s) to reduce electric lighting levels in areas where natural lighting contribution is significant.
- Individual Conference rooms to be equipped with wall mounted dimmer switch and ceiling or corner mounted occupancy sensors switches if wall mounted occupancy sensor is inappropriate for the room size.

o Custodial and storage rooms

- Provide occupancy sensor with automatic on-off capability in addition to manual switches. The sensor shall turn off the lights in the room via a pre-set but programmable interval after the room has been vacated.

o Mechanical, Electrical, MDF/IDF rooms, Attics, and other unoccupied spaces

- Manual switch.

o Emergency Lighting RESTRICTED

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
  - Exit Lights
    - Lithonia Model #LQMSW3RELN 120/277 (add ELM to number for battery backup).
  - Interior dual emergency lights
    - Dual-Lite LZ2 type.
  - Substitutions require written approval from LPS OMC and LPS Project Manager.

- Emergency lighting controls shall be equipped with bypass circuitry that will bypass all manually operated switches, lighting control systems, dimmers and occupancy sensors during power failure situations, design shall comply with applicable codes and regulations. Each area of luminaries or groups of luminaries shall be equipped with and controlled by a UL924 listed emergency lighting control units to allow the detection of localized power failures.
- If site is equipped with an emergency generator, all emergency lighting and exit signs shall be circuited to the emergency generator. Otherwise, emergency lighting and exit signs shall be equipped with battery backup of 20 minutes.
  - Frog Eyes with battery back shall be provided
  - General Lumineers with battery backup is PROHIBITED.
- Emergency lights that will also be used for general lighting shall be switched, dimmed, and controlled together with the general lighting for the same area but shall turn on (at full brightness for dimmable fixtures) upon loss of general power.
- LED exit sign luminaries shall operate continuously. Continuously operating luminaries other than LED exit luminaries are PROHIBITED.
- All emergency lights shall be powered by the emergency power source and may be controlled by a lighting control panel.
- Provide connection details for each style of control for the emergency lighting on the drawings. Also indicate on the drawings the style of control that is required for the luminary.

### 26 09 36 Modular Dimming

- RESTRICTED to specific manufacturers that have been previously approved by LPS:
  - Hubbell
  - Lutron
  - Lithonia

## 26 10 00 Medium-Voltage Electrical Distribution

### 26 18 00 Medium Voltage Circuit Protection Devices (called out as Motor and Circuit Disconnects)

- RESTRICTED to specific manufacturers that have been previously approved by LPS:
  - General Electric
  - Square D
  - Siemens
  - Westinghouse

## 26 20 00 Low-Voltage Electrical Distribution

## 26 22 00 Low Voltage Transformers

- Work in this section is RESTRICTED to specific products of specific manufacturers that have been previously approved by LPS.
  - Eaton/Cutler Hammer
  - General Electric
  - Square D
  - Westinghouse
- In the absence of other information, the following standards apply:
  - ANSI/NEMA ST 20 – Dry Type Transformers for General Applications.
- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Manufacturer's specification and product data cut sheets for all system components and devices, including:
    - Outline and support point dimensions of enclosures and accessories
    - Unit weight
    - Voltage, KVA, impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load,
    - Sound level, tap configurations, insulation system type and rated temperature rise.
    - Also requires LPS OMC review and comment to design team
  - Manufacturer Instructions: required
    - Also requires LPS OMC review and comment to design team
  - Closeout:
    - Submittals listed above updated to record status.
- Coordination
- Dry type-High Efficiency dual winding Transformers
  - ANSI/NEMA ST 20
    - Factory-assembled
    - Air cooled dry type transformers
  - Insulation system and average winding temperature rise for rated KVA as follows:
    - Rating K-Rated Transformer Rise (□C)
  - Case temperature shall not exceed 35°C rise above ambient at its warmest point.
  - Winding Taps for Transformers Less than 15 KVA:
    - Two 5 percent below rated voltage
    - Full capacity taps on primary winding.
    - Winding Taps for Transformers 15 KVA and Larger:

- Six 2.5% taps,
- 2 above and 4 below rated high voltage.

- ANSI/NEMA ST 20.
- Sound Levels:
  - Minimum 3 dBA less than NEMA ST20 standard sound level when factory tested according to IEEE Standard (57.12.91), "Test Code for Dry Distribution and Power Transformers":

| KVA Rating | Sound Level |
|---|---|
| 0-9 | 40 db |
| 10-50 | 45 db |
| 51-150 | 50 db |
| 151-300 | 55 db |
| 301-500 | 60 db |
| 750 | 64 db |

- Basis Impulse Level:
  - 10 KV for transformers less than 300 KVA
  - 30 KV for transformers 300 KVA and larger.
- Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- Coil Conductors:
  - Continuous copper primary and secondary windings with terminations brazed or welded.
- Enclosure:
  - ANSI/NEMA ST 20
  - Type 1.
- Provide lifting eyes or brackets

- 3 Phase Transformers
  - Delta Primary
  - Y Secondary
- Mounting
  - Transformers:
    - 30 KVA and smaller
      - Floor mounting preferred
      - Wall or trapeze mounting permitted
    - 45 KVA and larger
      - Floor mounting required
  - Transformers are PROHIBITED within plenums and above ceilings.
  - Mount transformers on vibration isolating pads suitable for isolating the transformer noise from the building structure.

        - Provide seismic restraints.
    - Install transformer to provide proper ventilation per NEC 450.9.
- Installation
    - Connect to transformer case with liquid tight or seal tight conduit
        - 2 feet minimum.
        - 4 feet maximum length with grounding bushing
        - Steel bonding bushings at both ends
    - Make conduit connections to side panel of enclosure.
    - Ground bushings required for all installations.
- Field Quality control
    - Check for damage and tight connections prior to energizing transformer
    - Measure primary and secondary voltages and make appropriate tap adjustments.

**26 24 00 Switchboards and Panelboards**

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
    - Cutler Hammer/Eaton
    - General Electric
    - Siemens
    - Square D
    - Westinghouse
- A single manufacturer per project or facility is required for all items specified in this section
- General
    - Main Electric Panel shall be oversized 25 percent to assure power and circuit breaker capacity for future requirements occurring after occupancy.
    - Distribution Panels shall be circuit breaker type of the "quick-make, quick-break" switch and fuse unit type.
    - All panels installed shall have 3/4" conduits stubbed into accessible location to accommodate remaining circuits in panel.
- Coordination
    - Fully rated system
    - Series rated system PROHIBITED
- Section Includes
    - Main Service switchboards
    - Distribution switchboards
    - Disconnect switches
    - Lighting and appliance branch circuit panelboards

- Molded Case Circuit Breakers
- Switch enclosures

- References
  - In the absence of other information, the following standards apply:
    - ANSI C12 - Code for Electricity Metering.
    - ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments.
    - ANSI C57.13 - Requirements for Instrument Transformers.
    - NEMA KS 1 - Enclosed Switches.
    - NEMA PB 2 - Dead Front Distribution Switchboards.
    - NEMA PB 2.1 - Instructions for Safe Handling, Installation, Operating and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
    - NEMA AB 1 - Molded Case Circuit Breakers.
    - NEMA PB 1 - Panelboards.
    - NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
    - NEMA KS 1 - Enclosed Switches.
- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Shop Drawing: required include:
    - Detailed front and side views of enclosures with overall dimensions
    - Conduit entrance locations and requirements
    - Nameplate legends (including short circuit bracing of bus structures).
      - Size and number of bus bars for each phase, neutral and ground
    - Switchboard instrument details.
      - Instructions for handling and installation of switchboard
    - Also requires LPS OMC review and comment to design team
    - Electrical characteristics including:
      - Voltage
      - Frame size
      - Trip ratings
      - Time-current curves of all equipment and components
    - Ratings and descriptions for all main, submain and distribution circuits.
    - Include outline drawings with dimensions and equipment ratings for:
      - Voltage
      - Capacity

- Horsepower
- Short circuit.

▪ Also requires LPS OMC review and comment to design team

o Manufacturer Instructions: required

o Design Data, Test Reports, Certificates, Manufacturers Field Reports

▪ Outline and support point dimensions

▪ Voltage, phase, wires (busses), main bus ampacity, main circuit breaker ampacity (where applicable) and integrated short circuit ampere ratings

▪ Include branch circuit breaker arrangement and sizes in a panelboard schedule

▪ Installation Instructions

o Closeout:

▪ Submittals listed above updated to record status

▪ Operation and Maintenance Data including spare parts list and the recommended maintenance procedures and intervals

▪ Extra Materials:

- Furnish three keys for each differently keyed panelboard.

**26 24 13 Switchboards**

- Construction and ratings
  - o Factory-assembled, dead front, metal enclosed and self-supporting switchboard assembly conforming to NEMA PB2 and complete from incoming line terminals to load-side terminations
    - ▪ All panels to be door in door
  - o IR (infra-red) thermal imaging inspection window in main switchgear enclosure. Window as approved or installed by switchgear manufacturer.
  - o Line Terminations:
    - ▪ Accessible from the front of the switchboard
    - ▪ Suitable for the conductor material (copper) used
  - o Main Section Devices:
    - ▪ Individually mounted and compartmented
  - o Distribution Section Devices:
    - ▪ Panel mounted
  - o Auxiliary Section Devices:
    - ▪ Individually mounted and compartmented
  - o Bus Material:
    - ▪ Copper only
    - ▪ Sized in accordance with NEMA PB 2
  - o Bus Connections:

        - Bolted
        - Accessible for maintenance
    - Horizontal bus feeding sub-sections shall be fully rated.
    - Bus bars shall be non-tapered throughout with bus spacing based on-air insulation.
        - Insulation: Poly-fiber material.
        - Cable splicing bus sections are PROHIBITED.
        - Bus all switchboard sections for the full height of the structure.
    - Provide a minimum 1 x 1/4-inch copper ground bus through the length of the switchboard.
    - Enclosure:
        - NEMA PB 2 Type 1, General Purpose.
        - Sections shall align at front and rear.
    - Switchboard Height:
        - NEMA PB2, 90 inches
            - Excluding floor sills, lifting members and pull boxes
    - Finish:
        - Manufacturer's standard light gray enamel over external surfaces.
        - Coat internal surfaces with minimum one coat corrosion-resisting paint or plate with cadmium or zinc.
    - Pull Section:
        - Same construction as switchboard, 30-inch width, depth, and height to match switchboard
    - Future Considerations:
        - Fully equip spaces for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents.
        - Continuous current rating
        - 25% expansion capacity of switchboards
- Switching and overcurrent protective devices
    - Breaker or Switch Fuse criteria:
        - Per electrical engineer
        - Bolt in breakers only
    - Provide 25% spare spaces for future loads.
    - Fusible Switch Assemblies Through 600 Amperes:
        - NEMA KS 1 quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle.
        - Provide interlock to prevent opening front cover with switch in ON position.

        - Handle lockable in OFF position.
        - Fuse Clips: Designed to accommodate Class R fuses.
    - Fusible Switch Assemblies, 800 Amperes and Larger:
        - Bolted pressure contact switches.
        - Fuse Clips shall be designed to accommodate Class L fuses.
        - Provide with electric trip and integral ground fault and blown fuse sensing and trips where required.
- Ground Fault
    - Ground Fault Sensor:
        - Zero sequence type.
    - Ground Fault Relay:
        - Adjustable ground fault sensitivity from 200 to 1200 amperes
            - Time delay adjustable.
            - Final setting by electrical engineer, not left at factory setting
        - Provide monitor panel with lamp to indicate relay operation, TEST and RESET control switches.

**26 24 16 Panelboards**

- Lighting and appliance branch circuit Panelboards
    - Fully rated.
        - Series rated breakers PROHIBITED.
    - NEMA PB1.
        - Circuit breaker type bolt in only.
    - Enclosure:
        - NEMA PB 1
        - Type 1.
    - Minimum Cabinet Size:
        - 6 inches deep
        - 20 inches wide for 480 volt and less panelboards.
    - Flush or surface cabinet front with door in hinged cover construction:
        - Trim shall be screw-on type
        - Door-in-door type with continuous piano hinges
    - Finish: manufacturer's standard gray enamel.
    - Construct adjacent panels to the same size.
        - The largest section shall therefore determine the physical size of the remaining panels.
    - Copper bus rated as scheduled on Panel Board Schedules.

- Copper ground bus.
- Extend vertical bussing the full height of the panelboards.
- Minimum of 50% spare spaces with 25% spare capacity.
- Height: 6 feet.
- Filler plates for unused spaces in panelboards.

- Molded Case Circuit Breakers:
  - NEMA AB 1 bolt-on type thermal magnetic trip circuit breakers with common trip handle for all poles.
  - Circuit breakers UL listed as:
    - Type SWD for lighting circuits.
    - Type HID for high intensity discharge lighting circuits
  - UL Class A ground fault interrupter circuit breakers
    - Stab or push-in style breakers are PROHIBITED.
- Provide typed circuit directory for each branch circuit panelboard.
- Disconnect Switches
  - NEMA Type 1: Indoors in dry locations.
  - NEMA Type 3R: For outdoors as required by the NEC or where "weatherproof" (wp) is required
  - Bonding bushings mandatory at both ends of all feeders
- Fusible Disconnect Switch Assemblies:
  - NEMA KS 1.
    - Heavy Duty (HD)
    - Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
  - Handle lockable in OFF position.
  - Fuse clips designed to accommodate Class R fuses.
- Nonfusible Disconnect Switch Assemblies:
  - NEMA KS 1
    - Heavy Duty (HD)
    - Quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position.
  - Handle lockable in OFF position.
  - Fractional Horsepower Motors:
    - Horsepower rated thermal overload switches or manual motor starters.
  - Provide ground bus.

- Provide neutral bus where called for
- Switches used as service entrance equipment shall be U.L. SE labeled.

- Switchgear and Switchboard Assemblies General
  - Visual and Mechanical Inspection:
    - Inspect for physical damage
    - Compare equipment nameplate information with latest single line diagram and report discrepancies.
    - Inspect for proper alignment, anchorage, and grounding.
    - Torque all bolted bus joints to manufacturer's written instructions.
    - Mark near bus joint with indelible ink with date and torque value.
    - Verify that gear is firmly attached to floor or wall.
    - Inspect all doors, panels and sections for damaged paint, dents, scratches, and proper fit.
  - Electrical Tests:
    - Insulation Resistance Test:
      - Measure the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute.
      - Use the manufacturers' recommended test voltages and the minimum acceptable resistance values.
    - Test Values
      - Bolt torque levels shall be in accordance with values specified by manufacturer.
- Transformers – dry type
  - Visual and Mechanical Inspection:
    - Inspect for physical damage
    - Compare equipment nameplate information with the engineer's latest single line diagram.
    - Check tightness of accessible bolted electrical joints
    - Specific inspections and mechanical tests as recommended by manufacturer.
  - Electrical Tests:
    - Insulation resistance tests shall be performed winding-to-winding and winding-to-ground.
    - Appropriate guard circuit shall be utilized under all bushings.
    - Winding resistance tests shall be made for each winding at the nominal tap position.
    - Test values
      - Insulation resistance test voltage, temperature corrected
- Execution Summary
  - Install switchboards on 4-inch-high concrete housekeeping pad.

- Bolt switchboard to floor or wall.
- Stub five empty 1-inch conduits to accessible location above ceiling out of each recessed panelboard.
- Circuit Directory:
  - Revise directory to reflect circuiting changes required to balance phase loads.
  - Note spare circuits in pencil.
  - Provide new, updated, typed panel schedule for any panel with two or more changes.
- Ground bushing feeder conduit only.
  - Required – both sides of all transitions.
- Neatly train and tie wrap conductors.
- Remove all debris.

### 26 24 19 Motor Control Centers

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
  - Cutler Hammer/Eaton
  - General Electric
  - Siemens
  - Square D
  - Westinghouse

## 26 25 00 Low-Voltage Enclosed Bus Assemblies

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
  - Cutler Hammer/Eaton
  - General Electric
  - Siemens
  - Square D
  - Westinghouse

## 26 27 00 Low Voltage Distribution Equipment

### 26 27 13 Metering

- RESTRICTED to specific manufacturers that have been previously approved by LPS:
  - Meter mounting device (as approved by Xcel):
    - Crouse-Hinds
    - Durham
    - Landis & Gyr

- Current transformer enclosure (as approved by Xcel):
  - Erikson
  - Hoffman.

**26 27 16 Electrical Cabinets and Enclosures**

- Work in this section is open to any product meeting the requirements of this Construction Standard.
- In the absence of other information, the following standards apply:
  - NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum.)
  - ANSI/NEMA ICS 1 - Industrial Control and Systems.
  - ANSI/NEMA ICS 4 - Terminal Blocks for Industrial Control Equipment and Systems.
  - ANSI/NEMA ICS 6 - Enclosures for Industrial Control Equipment and Systems.
- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Shop Drawing:
    - Cabinets:
      - Include dimensioned plan and elevation, front and side views, and any other pertinent elevation views
      - Knock-out or punching information.
    - Equipment Panels:
      - Include wiring schematic diagram, wiring diagram, outline drawing and construction diagram as described in ANSI/NEMA ICS 1.
    - Also requires LPS OMC review and comment to design team
  - Closeout:
    - Submittals listed above updated to record status.
- Hinged cover enclosures
  - Construction: NEMA 250; Type 1, steel.
  - Components: 14-gauge steel, white enamel finish.
  - Finish: manufacturer's standard enamel finish.
  - Covers:
    - REQUIRED Door in door configuration
    - Continuous hinge
    - Held closed by flush latch operable by key.
    - Panel for Mounting Terminal Blocks or Electrical devices
- Cabinets

- Cabinet Boxes:
  - Galvanized steel with removable end walls
  - 24 inches wide
  - 6 inches deep.
- Cabinet Fronts:
  - Steel
  - Surface type with concealed hinge and flush lock keyed separately for each system
  - Finish in gray baked enamel.

- Terminal blocks and accessories
  - Terminal Blocks:
    - ANSI/NEMA ICS 4
    - UL listed.
  - Power Terminals:
    - Unit construction type
    - Closed-back type
    - With tubular pressure screw connectors
    - Rated 600 volts.
  - Signal and Control Terminals:
    - Modular construction type
    - Channel mounted
    - Tubular pressure screw connectors
    - Rated 300 volts.
- Provide 3/4-inch-thick fire rated plywood backboard for mounting cabinet terminal blocks.
  - Do not paint.
- Fabrication
  - Shop-assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with ANSI/NEMA ICS 6.
  - Provide knockouts on enclosures.
  - Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosures.
- Execution Summary
  - Install cabinets, enclosures, and trim plumb.
  - Anchor securely to wall and structural supports at each corner, minimum.
  - Provide accessory feet for free-standing equipment enclosures.

## 26 27 26 Wiring Devices

- Work in this section is RESTRICTED to specific products of specific manufacturers that have been previously approved by LPS.
  - Wall Switches
    - Hubbell
    - Leviton
  - Receptacles
    - Hubbell
    - Leviton
  - Plates
    - STEEL ONLY
    - Leviton
    - Mulberry
    - Stenco
- Floor mounted service fittings:
  - Raceway Components
- Cord Drops:
  - Daniel Woodhead with strain relief at both ends.
- Submittals
  - Product Data: required.
    - Include configurations, finishes, and dimensions.
    - Also requires LPS OMC review and comment to design team
  - Samples:
    - Submit samples of each device.
    - Devices shall be reviewed and approved prior to procurement and installation.
    - Also requires LPS OMC review and comment to design team
  - Manufacturer Instructions: required
  - Closeout:
    - Submittals listed above updated to record status.
    - Samples excluded
- Coordination
  - Coordinate wiring connections, cords, and caps with:
    - Section 01 64 00 – Owner supplied products.
    - Section 10 14 00 - Signage.
    - Section 11 30 00 - Residential Equipment

        - Section 11 40 00 - Food Service Equipment.
        - Section 22 05 13 - Common Motor Requirements for Plumbing Equipment.
        - Section 23 05 13 - Common Motor Requirements for HVAC Equipment
        - Section 27 31 00 – Voice Communications Switching and Routing Equipment.
        - Section 27 41 16 – Integrated Audio Video Systems and Equipment
    - Prior to beginning work obtain the HVAC Equipment Schedule from Division 23 to determine the related electrical data required to wire each equipment item.
    - Refer to Coordination Schedule in Division 01 for additional information on Mechanical/Electrical coordination.
- Wall Switches
    - For Lighting Circuits and Single-Phase Motor Loads Under 1/2 HP:
        - NEMA WD1
            - AC quiet type, nylon, specification grade, UL listed with toggle handle, rated 20 amperes at 120-277 volts AC.
        - Mounting straps:
            - Metal and offer self-grounding or be equipped with a green hex-head ground screw.
        - Nylon handle
    - Pilot Light Type:
        - Lighted handle
    - Switches:
        - Screw connections only
        - Quick push-in wire connectors are PROHIBITED.
    - District approved Grounding Type or District approved equal:
        - Basis of design:
            - Single pole, 20A Leviton 5362
            - Three-way, 20A Hubbell No. 1223-I
            - Single pole, 20A keyed Hubbell No. 1221-L
            - Three-way, 20A, keyed Hubbell No. 1223-L
    - Classrooms:
        - Dual level switching and occupancy sensors
        - Occupancy sensors in classrooms shall be ceiling mounted to provide full coverage of the intended area.
        - Provide submittals for occupancy sensors for approval by LPS OMC and LPS Project Manager.
- Receptacles
    - Duplex, single, and special receptacles:

        - UL listed with a metal mounting strap with self-grounding and a hex-head green grounding screw
        - 20 amp
        - Specification Grade – Heavy Duty Industrial Grade
        - Nylon
    - Convenience and Straight-blade Receptacles:
        - NEMA WD 1
        - Leviton 5362 (I) Ivory or (W) White
        - District approved equivalent
    - Locking-Blade Receptacles:
        - NEMA WD 5.
    - Convenience Receptacle Configuration:
        - NEMA WD 1.
        - Type 5-20 R
        - Nylon face.
    - All receptacles connected to emergency circuits shall have a red face.
    - Specific-use Receptacle Configuration:
        - NEMA WD 1 or WD 5.
        - Black plastic face.
    - GFCI Receptacles:
        - Duplex convenience receptacle with integral ground fault current interrupter.
        - All receptacles within 6 feet of a water source shall be GFCI.
    - Isolated Ground Receptacles:
        - Duplex receptacle with metal strap for self-grounding and green hex-head source for isolated ground.
        - Orange face.
    - Tamper proof outlets typical throughout Elementary and Pre-school buildings or areas. Also include in all labs and clinics in all buildings.
- Floor mounted service fittings
    - Poke-through Fittings:
        - Floor boxes are PROHIBITED.
        - UL Listed as a fire-rated poke-through device or cast in place
            - Coordinate fire stops and smoke barriers in through-floor components.
            - Terminate in 4-inch square by 2-1/2-inch-deep junction box.
            - Device shall have two convenience receptacles and two individual low-tension openings.
- Wall dimmers:

- At selected areas only as coordinated and approved by LPS OMC and LPS Project Manager
- In general, use of dimmers is discouraged.
- LED Wall Dimmers:
  - NEMA WD 2
  - Linear slide type.
  - LED dimmer, 0-10 volts, Arrow/Hart SF-10P-V or equivalent.
- LED Wall Dimmer Rating:
  - 600-Watts minimum
  - Larger size to accommodate load

- Wall Plates
  - REQUIRED to be steel
  - Weatherproof Cover Plate: Gasketed cast metal with hinged gasketed device covers
  - Metallic Cover
- Cords and Caps
  - Pendant type outlets: Non-metallic box and strain relief required at both ends.
    - Daniel Woodhead, or approved equivalent
  - Straight-blade Attachment Plug: NEMA WD 1
  - Locking-blade Attachment Plug: NEMA WD 5
  - Attachment Plug Configuration:
    - Match receptacle configuration at outlet provided for equipment.
  - Cord Construction:
    - Oil-resistant thermoset insulated Type SJ, SJO, SO, SJOOW multi-conductor flexible cord with identified equipment grounding conductor, suitable for extra hard usage in damp locations.
  - Cord Size:
    - Suitable for connected load of equipment and rating of branch circuit overcurrent protection.
    - Not less than 12 AWG.
  - Use wire and cable with insulation suitable for temperatures encountered in heat-producing equipment.
  - Make conduit connections to equipment using flexible conduit.
    - Use liquid-tight flexible conduit in damp or wet locations. (motors, kitchen, technical education shops)
    - Cord drops: Use non-metallic boxes with strain relief.
  - Install pre-finished cord set where connection with attachment plug is indicated or specified, or use attachment plug with suitable strain-relief clamps.

- Provide suitable strain-relief clamps for cord connections to outlet boxes and equipment connection boxes.
- Make wiring connections in control panel or in wiring compartment of pre-wired equipment in accordance with manufacturer's instructions. Provide interconnecting wiring.
- Install disconnect switches, controllers, control stations, and control devices such as limit switches and temperature switches. Connect with conduit and wiring.

- Execution Summary
  - Drill opening for poke-through fitting installation in accordance with manufacturer's instructions.
  - Install wall switches OFF position down.
  - De-rate ganged dimmers per manufacturer.
  - Install convenience receptacles with grounding pole on top left where installed horizontally.
    - Grounding pole position shall be consistent throughout.
    - Provide GFCI protection where required by NEC.
  - Wire receptacles using pigtails for easy future service.
  - Install cover plates on switches and receptacles in all areas.
    - Use jumbo size plates for devices in masonry walls.
  - Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

## 26 28 00 Low Voltage Circuit Protective Devices

### 26 28 13 Current Limiting Fuses

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
  - Little Fuse Company
  - Bussman Corporation
- All fuses on the project shall be of the same manufacturer.
    - Intermixing of fuse type and manufacturers within the same series-connected circuit is PROHIBITED
  - Fuse types (e.g. KRP-C & FRS) of the same manufacturer within the same series- connected circuit is permitted and encouraged.
- In the absence of other information, the following standards apply:
  - ANSI C97.1 - Low Voltage Cartridge Fuses 600 Volts or Less
  - ANSI/UL 198C - High Interrupting Capacity Limiting Class L Fuses
  - ANSI/UL 198E - Class R Fuses
  - ANSI/UL 198G - Fuses for Supplementary Overcurrent Protection
  - ANSI/UL 512 - Fuse holders

- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Closeout: Submittals listed above updated to record status.
- Extra Materials:
  - Fuses:
    - Furnish to Owner 10% or two extra sets of three (whichever is greater) of each fuse type and rating installed on the project.
    - Place inside the spare fuse cabinet.
  - Fuse Puller:
    - Furnish 2
- Class R Fuses
  - Dual element time delay 250- and 600-volt AC
  - 1/10-600 amperes
  - Current limiting, with short circuit rating of 200,000 amperes symmetrical.
  - Comply with U.L. standard 198E.
    - Class RK1: LPN-R or LPS-R.
    - Class RK5: FRN-R or FRS-R.
- Fuse Blocks:
  - Install fuses in class R fuse blocks.
- Spare fuse cabinet
- Mount a spare fuse cabinet in the main electrical room.
  - NEMA 1 sized as required with hinged cover.
  - Minimum of 3 full width shelves.
  - Paint to match switchboard
  - Label "SPARE FUSE CABINET" in white core black phenolic on the front.
- Install fuses with labels to face towards the front of the switchboard.

**26 28 16 Enclosed Switches and Circuit Breakers**

- Coordinate with 26 24 00 Switchboards and Panelboards
- Bolt-in only
- Same manufacturer as panelboard, disconnecting device:
  - Cutler Hammer/Eaton
  - General Electric
  - Siemens
  - Square D

- Westinghouse

### 26 29 00 Low-Voltage Controllers

#### 26 29 13 Enclosed Controllers

- All 3 phase motors shall have 3 phase monitors installed.
- Magnetic motor starters
  - Full voltage
    - Light-duty PROHIBITED
  - Approved Manufacturers
    - General Electric
    - Siemens
    - Square D
    - Westinghouse
- Manual motor protection switches:
  - Approved Manufacturers
    - General Electric
    - Siemens
    - Square D
    - Westinghouse

## 26 30 00 Facility Electrical Power Generating and Storing Equipment

- Provide automatic emergency standby power source as required by applicable codes and regulations fueled by natural gas.

### 26 32 00 Packaged Generator Assemblies

- Work in this section is RESTRICTED to specific products of specific manufacturers that have been previously approved by LPS.
- Product requirements per 01 60 00 et seq.
  - Tier 2a manufacturer specific requirements performance criteria
  - NO SUBSTITUTES
    - Preferred manufacturer and basis of design
      - Generac
    - Acceptable alternate manufacturers requiring comparison pricing per 01 60 00 et seq
      - Caterpillar.
      - Cummins/Onan Engine Co.
      - Kohler Corp

        - Others to be pre-approved by LPS OMC and LPS Project Manager
- In the absence of other information, the following standards apply:
    - N.E.C. (NFPA 70) including but not limited to, Emergency and Standby Power Generation Systems
    - NFPA 30 - Flammable and Combustible Liquids Code
    - NFPA 31 - Standard for the Installation of Oil burning Equipment
    - NFPA 37 - Standard for the Installation and use of Stationary Combustion Engines and Gas Turbines
    - NFPA 110 - Standard for Emergency and Standby Power Systems.
    - Underwriters Laboratories
    - National Electric Manufacturers Association
    - National Electric Code
- Coordination:
    - SNP (serial network protocol) card to report EM generator status/ alarms to critical District personnel. Coordinate through LPS OMC and LPS Project Manager.
        - Preferred Fuel Type: Natural Gas
    - Concrete housekeeping pad
    - Rodent proof generator
    - Coordinate Division 22 piping and connection requirements.
- Submittals
    - Submit for approval, in electronic format appropriate to submittal:
        - Selective coordination to protect generator set.
            - Also requires LPS OMC review and comment to design team
        - Complete shop drawings
            - Also requires LPS OMC review and comment to design team
        - Catalog cuts marked to show:
            - Specific manufacturer’s model numbers
            - Factory output ratings
            - Fuel type and consumption rate
            - Ventilation and combustion air requirements
            - Dimensions
            - Weight
            - Any special installation instructions for the engine-generator set
            - All major items of auxiliary equipment including:
                - Generator set including plans and elevations or risers clearly indicating entrance or connection points for all the inter-connections necessary.

    - Automatic transfer switch
    - Remote annunciator with on-site installation requirements to be tied to BAS
    - Locate to be coordinated with LPS OMC and LPS PM
    - Diagrams including schematics and a single, integrated interconnection wiring diagram for all equipment to be provided.
    - Separate wiring diagrams for various parts of the system which require interconnection will not be accepted.
    - Legends for all devices on all drawings.
    - Color samples for paint finish.
    - Control panel and remote annunciator.
    - Battery and charger.
    - Exhaust system
  - Also requires LPS OMC review and comment to design team
- Closeout
  - Submittals listed above, updated to as-built record status
    - In appropriate electronic format (AutoCAD, PDF, etc.)
  - Operation and Maintenance instruction manuals on the complete system and itemized components.
  - Detailed operation and maintenance procedures to the Owner's operating personnel or representatives after successful completion of the specified testing. Include code required periodic exercise procedures.
  - 3 electronic copies of each test and procedure used.
  - Keys (6)
  - One-hour on-site training
- Guarantee specified equipment against defective material and workmanship under the terms of the manufacturer's and dealer's standard published warranty.
  - Minimum period of one year from the date of the acceptance of the system.
  - Installing contractor shall be responsible for labor and travel time and mileage for necessary repairs at the jobsite.
- Supplier must have serviceable parts readily available.
- Generator Set
  - Products submitted must be manufactured as a complete unit, and be supplied by that manufacturer’s franchised, authorized dealer only.
  - Under no circumstances will assemblers of engine generator sets be acceptable.
  - Authorized dealers must have complete, local replacement parts stock, and shop and field service capability for all equipment to be supplied, with a facility within 90 miles of the job location.

- Factory built complete unit shipped to the job site and unloaded by an authorized dealer/distributor.
- U.L. 2200 listed.

- Engine
  - Natural gas preferred.
  - Two-stroke cycle engines will not be considered
  - Maximum operating speed: 1800 RPM.
  - Fuel, full flow lubricating oil, and dry type air filters, lube oil cooler, fuel transfer pump, fuel filter, fuel priming pump, and unit mounted instruments including a fuel pressure gauge, water temperature gauge, and lubricating oil pressure gauge.
  - Engine governor: Standard mechanical type to maintain frequency regulation of not more than 2% from no load to full rated load with recovery within 2 seconds and 0.5% steady state.
  - Safety shut offs for high water temperature, low oil pressure, over speed and engine over crank.
  - Guards over all exposed moving parts as required by OSHA.
- Installation
  - Mount the unit on a structural sub-base with suitable vibration isolators for noise and vibration attenuation.
    - Securely fasten to housekeeping pad
    - Rodent-resistant construction with generator manufacturer's approved installation intended for this purpose.
- Generator:
  - Manufacturer rated for continuous standby service with size rating per engineer and derated for the elevation and wide temperature range.
  - 4 pole reconnectable brushless synchronous generator with brushless excitor.
  - Three-phase single bearing synchronous type directly connected to the engine through a flexible disc drive.
    - Gear reductions of any kind will not be allowed.
  - Built to NEMA standards, except that maximum temperature rise at its specified output shall be limited to 130 (standby) degrees C. rise by resistance over a 40 degrees C. ambient.
  - Minimum Class F insulation:
    - Materials shall not support fungus growth.
  - Incorporate reactive droop compensation and include a resettable thermal protector for exciter/regulator protection against extended low power factor operation.
  - Rotor:
    - Include amortisseur windings.
  - Generator mounted volts per hertz type exciter/regulator provided to match the characteristics of the generator the turbo-charged engine.

- Voltage regulation:
  - Plus, or minus 1% from no load to full rated load.
- Readily accessible voltage drop, voltage level and voltage gain controls.
- Voltage level adjustment:
  - Minimum of plus or minus 5%.
- Solid state regulator module:
  - Shock mounted and epoxy encapsulated for protection against vibration and atmospheric deterioration.

- Cooling System:
  - Engine mounted radiator with a blower-type (pusher) fan to maintain safe engine temperature at operating ambient temperature of 120 degrees F. at the installed elevation.
  - Equip radiator with a duct adapter flange and a lockable cap.
  - Air restriction for the radiator system shall not exceed .5 inches water.
- Exhaust System:
  - Properly sized, critical silencing level muffler and piping including a seamless, bellows type flexible connector.
  - Horizontally mounted muffler supported independently of the engine, so that none of its weight is supported by the engine turbocharger.
  - Threaded or flanged fittings with the proper gaskets.
    - Clamp-type fittings are PROHIBITED.
- Starting motor:
  - DC electric starting system with positive engagement motor.
  - Motor voltage as recommended by the engine manufacturer.
- Automatic Control:
  - Fully automatic generator set start-stop controls in the generator control panel.
  - Provide shutdown for:
    - Low oil pressure
    - High water temperature
    - Overspeed
    - Overcrank
    - 3PDT auxiliary relay for activating accessory items.
- Jacket Water Heater:
  - Unit mounted thermal circulation type water heater incorporating a thermostatic switch to maintain engine jacket water to 80 degrees F.
  - 120 volts, single phase, 60 Hertz.
  - Vee type engines require one heater per each bank of cylinders.

- Batteries:
  - Lead-acid storage battery set for maintenance free, heavy duty diesel starting.
  - Battery voltage compatible with the starting system.
  - Battery set rated not less than 700 cold cranking amps at 0 degrees F.
- Battery Racks:
  - Metal treated to be resistant to deterioration by battery electrolyte.
  - Construct so that non-conductive insulation material directly supports the cells.
- Battery Charger:
  - Dual rated, DC regulated, line compensated battery charger to automatically recharge the batteries.
  - Float at 2.17 volts per cell and equalize at 2.33 volts per cell.
  - Include:
    - Overload protection
    - Silicone diode full wave rectifiers
    - Voltage surge suppressor
    - DC ammeter
    - DC voltmeter
    - Fused AC input.
  - AC input voltage:
    - 120 volts, single phase.
  - Amperage output:
    - 10 amperes minimum.
  - Wall mounting type in NEMA 1 enclosure, by the generator supplier, mounted in the housing and connected to the battery on the DC side.
- Main Line Circuit Breakers:
  - Main-line, molded case circuit breaker mounted upon and sized to the output of the generator installed as a load circuit interruption and protection device.
  - Operate both manually for normal protection device.
  - Operate both manually for normal switching functions and automatically during overload and short circuit conditions.
  - Equipped with bus bars on the line side for bolted connection of the generator leads, and output lugs for on the line side of the circuit breaker.
  - Size at 115% of generator full load current.
  - The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection.
  - Generator exciter field circuit breakers do not meet the above electrical standards and are unacceptable for line protection.
- Generator Control Panel:

- A generator mounted NEMA 1 type, vibration isolated 14-gauge steel control panel containing, but not be limited to the following equipment:
  - Frequency meter, 3 1/2-inch, dial type, 45-65 Hz.
  - Voltmeter, 3 1/2-inch, 2% accuracy.
  - Ammeter, 3 1/2-inch, 2% accuracy.
  - Ammeter (4 position)-Voltmeter (7 position) phase selector switch.
  - Automatic starting control as specified.
  - Voltage level adjustment rheostat.
  - Dry contacts for remote alarms wired to terminal strips.
  - Individual fault indicator lights for low oil pressure, high water temperature, overspeed, low fuel, and overcrank and a push to test indicator light.
  - A 3 PDT aux relay connected to a terminal strip.
  - A 4-position function switch marked "auto", "manual", "off-reset" and "stop".
  - Running time meter, oil pressure and water temperature gauges.
  - Hinged, solid protective cover with provision for locking.

- Annunciator Panel:
  - Panel for remote mounting to give audible and visual warning of all the above listed alarm conditions in the generator system. The panel shall conform to the requirements for the National Electrical Code, Section 700, and the National Fire Protection Association, Section 110 - Level 2.
  - The panel shall be remote mounted in the Facilitator’s Office and shall include all alarms required by this guideline.
    - Running
    - Out of Auto
    - Failed to Start
    - High or Low Water Temperature
    - Battery Charger
    - Load Transfer
    - Overcrank
    - Low Fuel

- Enclosure:
  - Enclose the complete unit with all accessories in an insulated, sound attenuated, weatherproof enclosure suitable for outdoor use.
  - Provide necessary heavy gauge metal screens to prevent small rodent access.
  - Provide access doors with full length piano type hinges to allow access to all components for normal maintenance and inspection.
  - Doors: Locking handles with matching keys.

- Rainproof louvers sized for the generator manufacturers recommended air flow through the housing.
- Mount the silencing muffler on top of the enclosure as specified with a rain collar roof penetration.
- Rodent-proof all enclosures as per Generator manufacturer's original equipment and written requirements.

- Automatic Load Transfer Switch(es) (ATS):
  - Provide number of ATS units required by NEC and State code.
    - Life safety systems
    - Owner provided power system, as directed by LPS OMC
  - Number of poles and current ratings as required for a normal and emergency source voltage.
  - Listed per U.L. Standard 1008 as recognized components for emergency systems and rated for 125% of total system load.
  - Automatic pickup voltage adjustable from 85% to 100% of nominal (set at 90%)
  - Dropout voltage adjustable from 75% to 98% of the pickup value (set at 85%).
  - Electrically operated, mechanically held, and be suitable for continuous duty in an unventilated enclosure at 100% rated load.
  - Inherently double throw so both sets of contacts move simultaneously when the switch is transferring.
  - Mechanically interlocked to ensure that only one side can be closed at a time.
  - Main contacts:
    - Silver alloy wiping action type
    - Protected by arcing contacts in sizes above 400 amperes.
  - Switch and relay contacts, coils, springs, and control elements shall be removable from the front of the transfer switch without removal of the switch panels from the enclosure and without disconnection of drive linkages or power conductors.
  - Sensing and control relays:
    - Continuous duty industrial control type
    - Minimum contact rating of 10 amperes.
  - Automatic Transfer Switches utilizing components of molded case circuit breakers, circuit interrupters, disconnect switches, or parts thereof which were not intended for repetitive switching are PROHIBITED.
  - An overload or short-circuit shall not cause the transfer switch to go into a neutral position.
  - Harnessing between the transfer switch and the control panel shall have built in disconnect feature for routine maintenance.
  - Supply in a NEMA 1 enclosure for wall mounting.
  - Manufacturers:

        - As manufactured by the generator set manufacturer or furnished with generator by generator set manufacturer.

- Accessories:
    - A time delay to override momentary normal source outages to delay all transfer switch and engine starting signals.
        - Field adjustable from 0.5 to 6 seconds
        - Factory set at 3 seconds.
    - A time delay on retransfer to normal source.
        - Automatically bypassed if the emergency source fails and normal source is available.
        - Field adjustable from 0 to 10 minutes
        - Factory set at 10 minutes.
    - An unloaded running time delay for emergency generator cool-down.
        - Field adjustable from 0 to 5 minutes
        - Factory set at 5 minutes.
    - Automatic exercise timer with programmable logic and with or without load pickup selection.
        - Programmable and set to exercise at certain times as designated by LPS OMC and LPS Project Manager.
    - Independent single-phase voltage and frequency sensing of the emergency source.
        - Adjustable from 85% to 100% of nominal.
        - Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.
    - A contact that closes when normal source fails for initiating engine starting, rated 10 amperes.
        - Gold plated for low voltage service.
    - Panel lamps to show switch position.
    - One set of normally open and one set of normally closed auxiliary contacts on each side of the switch.
    - A test switch to momentarily simulate normal source failure.
- Installation by manufacturer/supplier
    - Unload the equipment and ensure that it is properly set in place with all vibration isolators properly installed.
    - Provide technical assistance to the electrical contractor as required for interconnection of the system.
- Testing
    - Provide results of 100% load bank test at the factory prior to shipping.
    - Upon completion of the installation:
        - Test the generator system to confirm:

- It is free of any defects
- The phase rotation matches the incoming utility
- It will start automatically within code required time
- Will automatically transfer and retransfer the loads.

- The system shall be subjected to full rated load test using dry type load banks designed for this purpose.
- The load bank shall be capable of definite and precise incremental loading
  - The load settings shall not be dependent upon the generator control instrumentation to read amperage and voltage of each phase.
    - Test instrumentation will serve as a check of the generator set meters.
- Load bank testing shall be required at the factory and the results are to be received on site before installation may begin.
- All load tests (at the factory and on site) to be a minimum of 2 hours and recorded on a log showing load, ambient temperature, oil pressure, etc. on 10-minute intervals.
- After testing and startup is completed, completely fill the fuel tank, and add oil to the engine, as necessary.

- Connections:
  - Due to vibration, install stranded wire from generator to:
    - Remote annunciator
    - Block Heater
    - Battery Charger
  - Provide independent branch circuitry (IBC) for block heater.
  - Provide IBC for charger, both served from life safety panel.
- Labeling Requirements:
  - Provide Nameplate Label as per Section 26 05 53.
    - Include power source
- Start-up and Instruction
  - On completion of the installation, start-up the generator set by manufacturer's factory trained service representative as a part of and immediately prior to the specified testing.
  - LPS OMC and LPS OMC generator maintenance contractor to be present for start-up and instruction
    - Coordinate maintenance expectations during warranty period

**26 35 00 Power Filters and Conditioners**

- Work in this section is RESTRICTED to specific products of specific manufacturers that have been previously approved by LPS.
  - Current Technologies
  - Liebert

- Coordination
  - Section 26 05 26 – Grounding and Bonding for Electrical Systems
  - Section 26 05 53 - Identification for Electrical Systems
  - Section 26 24 00 – Switchboards and Panelboards
- References
  - In the absence of other information, the following standards apply:
    - ANSI/IEEE compliance; Comply with ANSI/IEEE C62.1, C62.41 and C62.45.
    - NEC as applicable to construction and Article 280 for installation.
- Submittals
  - Product Data: required
    - Also requires LPS OMC review and comment to design team
  - Shop Drawing: required
    - Also requires LPS OMC review and comment to design team
- Design Data, Test Reports, Certificates, Manufacturer Instructions, Manufacturer Field Reports:
  - TVSS specifications
  - Latest edition of the UL 1449 surge suppression rating Category C3 for the Filter.
  - Also requires LPS OMC review and comment to design team
- Closeout:
  - Submittals listed above updated to record status.
  - Maintenance manuals
- Warranty
  - TVSS shall be warranted for 5 years
  - Label equipment on inside of door with length of warranty from date of acceptance.
- Maintenance Service
  - Local service support shall be provided for TVSS such that upon failure, a replacement shall be available within twenty-four hours.
- TVSS
  - Mechanical and electrical requirements suitable for application in category C3 environments as described in ANSI/IEEE C62.41.
  - TVSS must not affect the performance of the frequency corrected slave clock system.
- Manufacturer Qualifications:
  - Regularly engaged in the manufacture of TVSS product for category C3 (ANSI/IEEE C62.41)
  - Products have been in satisfactory service for not less than ten years.
- TVSS Installation:

- The conductors are to be as straight and short as practically possible; not to exceed 10 feet in length.
- Install an appropriately sized manual safety/disconnect switch or circuit breaker before and in line with TVSS.
- Capable of electrically isolating the TVSS from the electrical service for repair without interrupting service to the building.
- TVSS units must be downstream of main distribution center (MDC) disconnect.

- TVSS shall be self-diagnostic, with panel lamp to show status of TVSS

## 26 50 00 Lighting

- General Guidelines
  - All new lighting in LPS shall be LED.
    - Indoor lighting shall be 4000-4100k
    - Outdoor lighting shall be 3000-3500k
    - T-8 or T-5 fluorescents are to be used where they currently exist unless 50% of the light fixtures in the space are being replaced.
      - Coordinate with 26 51 15 Lamps
      - Coordinate with 26 51 17 Ballasts, Controls and Accessories
  - Comply with State adopted IECC.
  - Lighting design shall comply with guidelines and follow recommendations and procedures of the Illuminating Engineering Society of North America (IESNA) in its "Lighting Handbook" and "Recommended Practice on Lighting for Educational Facilities 10th Edition, ANSI/IESNA RP-3-00," as well as other documents referenced herein.
  - Comply with latest ASHRAE/IESNA 90.1 standard.
    - Lighting Power Density (LPD) requirements
      - Include actual LPD versus current standard (defined in space-by-space section) on room schedule.
  - Lighting Designer/Electrical Engineer to provide the following:
    - Room by room schedule of luminaires existing in building including: Quantity removed, manufacturer, luminaire type, number of lamps, Wattage, etc. as well as the same details on the luminaires proposed to replace these. Include "Total Building kW Removed" at the bottom of the schedule. Schedules may appear on the Contract Documents or in additional submittals. Xcel Energy or their representative may request these schedules in Microsoft excel to process rebates.
    - Photometric plans with a maximum of a 3' spacing grid, shall be provided in the Contract Documents drawing set showing every occupied space receiving new lighting. Provide a schedule showing every room (occupied and non-occupied) and the average designed illuminance. Average illuminance shall be defined from taking the average illuminance in the room area. For classrooms, auditoria, cafeterias, gymnasiums, and conference rooms, this average shall be calculated four feet from all walls. The maximum illuminance permitted in the space shall not exceed twice of the average targeted value for that space defined below in the "LPS – Standard for Average Illumination Levels" table.

        - Lumen depreciation factor of 0.88 shall be used for all photometric calculations.
    - Lighting Designer/Electrical Engineer to coordinate all documentation requirements for Xcel rebates.
    - Provide uniform light distribution in all learning and working spaces. Interior lighting systems shall provide illumination without discomfort caused by glare. Consider reflectance of room surfaces and coordinate with architectural finishes.
    - Avoid harsh or extremely bright lighting. Minimize veiling reflections in task details.
    - Utilize daylight harvesting as required by code. Daylight harvesting shall be integrated with electric lighting, photo sensors, and dimmer controls.
        - To the greatest extent possible, daylighting design and daylight harvesting is to be utilized in gymnasiums, cafeterias, cafetorium, and commons areas that are receiving natural light.
    - LPS may elect to procure commissioning services of lighting system. This decision will be made and communicated during the design process.
    - Provide LEDs in lighted display cases.
    - The lighting controls in Theatrical applications shall be interfaced with the Fire Alarm System to cause house lighting to be forced on during alarm conditions, regardless of manual or automatic control settings.
- Luminaires
    - All luminaires shall be supplied with individual drivers.
    - If special or custom luminaires are considered, they will require approval of LPS OMC and LPS Project Manager.
    - Utilize high color-rendering source.
        - The minimum CRI for all spaces shall be 80.
        - The minimum CRI for Visual Art Rooms in Middle and High Schools shall be 90. (Theatre lighting is specified elsewhere.)
    - Luminaires shall be capable of dimming to 5% output, except in auditoria where they shall dim to 0%.
    - Wall mounted light fixtures shall follow ADA requirements.
- Lighting replacement projects
    - Space redesign with consideration of photometric and uniformity is required. One- for-one replacements are not acceptable without photometric plans provided to validate existing layout.
    - If retrofitting the lighting in a room, retrofit all luminaires.
    - One control point is needed per room unless otherwise directed by LPS OMC and LPS Project Manager.
    - Each classroom, office, conference room, cafeteria, and gym shall be equipped with dimming and multi-level controls.
- Illumination Criteria
    - Per the Illuminating Engineering Society
- Specific Lighting Criteria

- Classrooms (General, Science, Visual Art, and Computer)
  - Incorporate daylight harvesting into classroom lighting where required by the state adopted IECC Code
  - Uniformity of illuminance on the work surfaces are important – especially on the core desk space.
  - During the design development phase provide point to point lighting calculations to graphically demonstrate the light levels on all room surfaces.
  - "Circadian" or "Tunable" LEDs shall be utilized in all classrooms . Coordinate locations with LPS OMC and LPS Project Manager.
    - These lights are not required in other spaces.
    - 8 button function for all Tunable Lighting
      - On
      - Off
      - Dim Up
      - Dim Down
      - 3000
      - 3500
      - 4000
      - 5000
    - Luminaire styles shall be like those described in General Classrooms.
- Library
  - Lighting Designer/Electrical Engineer may recommend multiple zones of control to LPS OMC and LPS Project Manager.
- Gymnasium Lighting
  - Consider illuminating gyms with daylighting for daytime use, using skylights, tubular daylighting devices, high semi-transparent panels, or clerestories.
  - Provide electric lighting for nighttime use and daytime supplementary lighting using suspended high-bay LED luminaires with protective wire guards.
  - Consider daylight sensors to selectively dim the lamps in response to the daylight illuminance.
- Career and Technical Education (CTE) Classrooms
  - Same as classrooms, or industrial surface-mounted, or suspended open LED luminaire if appropriate to the architectural design.
  - Specify appropriate fixtures to eliminate dust collection in high dust concentration areas
  - Manual on and manual off in wood shop, metal shops, pool areas, and Tech Labs
- Mechanical, Electrical, MDF, & IDF Rooms
  - Strip style LED luminaire with wire guard.
  - Consider wall mounted luminaires in combination with suspended.

- Elevator Pits
  - LED luminaire with guard, and with IP ("Ingress Prevention") Rating of IP 64.
- Exit Signs
  - LED type.
- Casework
  - LED tape lights may be utilized in Science Classrooms (as task lighting) and in Display Cases. These lights shall be controlled separately from other luminaires in the space.

- Luminaires
  - Indoor lighting shall be 4000-4100k
  - Outdoor lighting shall be 3000-3500k
  - Luminaires not available for a specific requirements, other color temperatures must be approved by LPS OMC and LPS Project Manager.
  - Selection of luminaires shall be made based on lighting characteristics (including uniform distribution and glare), appearance, cost, maintainability, energy efficiency, and resistance to vandalism.
  - Each luminaire shall be fully specified and correlated with the Fixture Schedule.
  - On the Schedule, provide full data for basis of design of each luminaire on lamps (if applicable), luminaire type, input wattage, and mounting type.
- Lighting Power
  - Lighting branch circuits shall be 20 amp, unless otherwise required by the system.
  - Provide a distributed balanced load on all phases for panels and branch circuits.
  - Lighting panel boards shall be 480/277-volt, 3-phase, and 4-wire, with thermal- magnetic bolt-on type branch circuit breakers if service exists in building. Otherwise, at small sites or smaller buildings at large sites may use 208/120-volt, 3- phase, and 4-wire panels.
- Emergency Lighting
  - Emergency lighting fixtures shall be located nearest to the exit in a space.
  - All emergency system luminaries shall be labeled as being part of the emergency lighting system with labeling similar.
  - Powered off the Emergency Generator
    - Where no generator, Frogs Eyes are the only approved egress lighting

**26 51 13 Light Fixtures**

- Match existing building fixtures to the greatest degree possible
- Provide LPS Electricians fixture submittals during Design Development for approval to incorporate in the bid documents
- Standard 2' x 4':
  - Acuity Lithonia, LED Troffer, 4000K
  - GE

- Philips

- Outdoor small-area wall-mount Security Light:
  - Lumark Crosstour LED, 3000K, 20W
  - Sole Source
- Exit Signs:
  - Sole source
  - Acuity Lithonia Exit Sign with Battery Backup LED
- Emergency Lights:
  - Sole source
  - Dual-Lite wall-mount Indoor Emergency Light, LZ-series LED, 3000K

### 26 51 15 Lamps

- Fluorescent tubes and bulbs will be of an energy-efficient type approved for use by LPS OMC and LPS Project Manager.
- Where special lamps are indicated, furnish exactly as specified and pre-approved by the LPS OMC and LPS Project Manager.
- Mercury vapor lamps and incandescent bulbs are PROHIBITED.

### 26 51 17 Ballasts, Controls and Accessories

- Electronic ballasts shall be low consumption
- Electronic ballasts with 5-year warranty:
  - General Electric
  - Advance.
- Series ballasts are PROHIBITED.

## 26 55 00 Special Purpose Lighting

### 26 55 61 Theatrical Lighting

- Work in this section is RESTRICTED to specific manufacturers that have been previously approved by LPS.
- Consult with during Schematic Design and provide LPS Electricians and LPS third party consultant submittals during Design Development for approval to incorporate in the bid documents.

## 26 56 00 Exterior Lighting

- When lighted for security purposes, are to utilize LED lighting controlled through photo cells
- Exterior fixtures shall be vandal resistant.
- Parking lot lighting shall be controlled by time clock for energy management purposes.
- Work in this section is RESTRICTED to specific products of specific manufacturers that have been previously approved by LPS.

- Product requirements per 01 60 00 et seq.
  - Tier 2a manufacturer specific requirements performance criteria
  - NO SUBSTITUTES
  - Preferred time clocks and basis of design
    - Intermatic
      - ET70115C
      - ET70115CR
      - ET70115CR8
      - ET70115CR24
      - ET70215C
      - ET70215CR
      - ET70215CR8
      - ET70215CR24.
  - Acceptable alternate manufacturers requiring comparison pricing per 01 60 00 et seq
    - Others to be pre-approved by LPS OMC and LPS Project Manager during Design Development

**26 56 13 Lighting Poles and Standards**

- Lighting poles shall be constructed so that all metallic parts are continuously grounded, with grounding stud inside hand-hole.
- Poles shall be set on concrete base, with top elevation 3'-0" above grade at parking areas and 6" above grade at all other areas.
- Pole material and wall thickness shall be sufficient to support effective projected area of luminaire and pole, without damage to lamp filaments, for a wind-gust factor of 130 mph.
- Refer to 26 51 13 Light Fixtures for fixture requirements

**END OF DIVISION 26**