E. Sample collection: Collect samples utilizing the methodology described as follows:

1. Faucets: Moisten the outlet by allowing water to trickle through the opening. A sterile Dacron swab is inserted and rotated four times around the inner circumference and moving up the faucet as far as the swab will reach. Replace the swab into the container. If the swab system does not contain a transport medium, then allow 0.5 ml of water to flow from the faucet into the container to keep the swab moist. The Culturette II System (Becton Dickinson) has a self-contained transport medium, and it is not necessary to add outlet water to the swabs.
2. Shower Head: Moisten the shower head by allowing water to trickle through the opening. Rotate the swab over the entire surface of the shower head 4 times. Place swab into the container. If the swab system does not contain a transport medium, then allow 0.5 ml of water to flow from the shower head into the container.
3. Hot Water Tank: Open the drain valve at the base of the tank. Collect 10 to 50 ml immediately into a sterile specimen container. Then let the water drain out of the pipe for 15-30 seconds to flush out residual water within the drain pipe and then collect another 10 to 50 ml into a second specimen container. This procedure ensures that both residual water in the drain pipe and water from the tank are sampled. Scale and sediment often harbor Legionella bacteria, so it is worthwhile to obtain scale or sediment from tanks or distal sites. Heavy "syrupy" specimens from the bottom of hot water tanks, however, often will not yield the organism.

    a. Samples should be refrigerated at 2-8° C. until processing. Swab specimens generally give higher yields than water taken from the same site.
    b. BCYE medium with dyes, glycine, vancomycin and polymyxin will be used (Remel #01338, BBL #99648). Plates overgrown with microflora will undergo acid treatment.

F. Action Limits: Test results indicating the Legionella CFU/mL shall be acted upon as follows:

1. Individual Sample Test of less than 10 CFU/mL: Report results with recommendation for monthly followup testing. After 6 months of followup testing with no test above 10 CFU/mL, testing may be suspended. If samples from 30% or more of tested outlets test positive for Legionella, report results with recommendation for prompt cleaning and/or biocide treatment.
2. Individual Sample Test Result Between 10 and 99 CFU/mL: Report results with recommendation for prompt cleaning and/or biocide treatment.
3. Individual Sample Test Result of 100 CFU/mL or Higher: Report results and recommend immediate cleaning and/or biocide treatment with prompt steps to avoid exposure.

END OF SECTION 22 11 00

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SECTION 22 60 00 - PLUMBING- SPECIAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the following:

1. Medical compressed air system
2. Medical gas systems
3. Pipe and fittings
4. Piping system accessories
5. Medical vacuum systems
6. Waste anesthetic gas disposal systems

1.3 RELATED SECTIONS

A. Section 22 05 00: Common Materials and Methods for Plumbing Systems

B. Section 22 05 48: Vibration Isolation and Seismic Restraints for Plumbing Systems

C. Section 22 10 00: Plumbing Systems

D. Division 26 - Electrical.

1.4 REFERENCE STANDARDS

A. Office of Statewide Planning and Development (OSHPD)

B. Guidelines for Construction and Equipment of Hospital and Medical Facilities (2010)

C. NFPA 99, 2012 - Standard for Health Care Facilities

D. UL - Listings of Reexamination Service

1.5 SUBMITTALS

A. Provide submittals in accordance with Section 01 33 00 "Submittal Procedures" in sufficient detail to verify full compliance with requirements of the contract documents.

B. Submit detailed drawings of pipe anchors, showing all forces, for review before installation.

1.6 WARRANTY AND CONTRACT CLOSEOUT

A. Warranty

1. Refer to warranty and closeout requirements in Division 01.

B. Contract Closeout

1. Comply with the requirements of Division 01.
2. Include information for all products specified in this section in the operating and maintenance manual.
3. Provide the following as specified in this section or Section 22 05 00:

   a. Testing and cleaning reports, certified by contractor, for each system.
   b. "Record drawings".
   c. Instructions and demonstration to the Owner's representatives for the time period specified in Section 22 05 00.
   d. Installation and testing certifications for medical gas systems.
   e. Framed valve number schedule.
   f. Qualification certificates for medical gas system installers complying with ASSE 6010.

1.7 CERTIFICATIONS

A. Medical Gas Systems

1. Provide certification signed and sealed by a Professional Engineer that medical gas systems have been installed and inspected in accordance with NFPA standards referenced above.
2. Provide certification of testing as required by article titled TESTING AND CERTIFICATION OF MEDICAL GAS SYSTEMS in Part 3 of this section.

1.8 QUALIFICATION OF MEDICAL GAS BRAZER INSTALLERS AND WELDERS

A. Medical gas brazers and installers shall be certified in accordance with Section IX Welding and Brazing Requirements of ASME Boiler and Pressure Vessel Code or AWS B2.2 for brazing procedures and performers qualifications and/or ASSE 6010 Medical Gas System Installers Professional Qualification Standards 2006. Medical gas equipment manufacturers personnel assembling medical air, instrument air, medical vacuum and WAGD factory packaged source equipment plants shall also be ASSE 6010 certified.

B. Certificates: Provide a written statement by authorized representative indicating medical gas system installer's qualifications.

1.9 DELIVERY, STORAGE, AND HANDLING

1.10 SEISMIC DESIGN

A. Refer to Section 22 05 00, Article 1.10, Paragraph B.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide products of the following manufacture:

1. Medical Gas Systems - Oxygen, Vacuum, Nitrous Oxide, Anesthesia Scavenger Vacuum, Nitrogen, Compresses Air – Pipeline Equipment

a. Beacon Medaes
b. Chemetron Corp.
c. Puritan-Bennett Corp.
d. Amico

2. Pipe and Fittings

a. General Pipe and Fitting Materials

1) Unless otherwise specified, any United States manufacturer whose products comply with the reference standards.

b. Basic Pipe and Fitting Materials and Accessories not specified in this section: Refer to Section 22 05 00.

3. Valves

a. Basic Valve Types Not Specified in this Section: Refer to Section 22 05 00.

b. Type MGV, Medical Gas System Valves

1) Same manufacturer as Medical Gas System outlets and accessories.

2.2 MEDICAL GAS SYSTEMS - OXYGEN, VACUUM, COMPRESSED AIR, NITROUS OXIDE, ANESTHESIA VACUUM, NITROGEN

A. Wherever the term medical gas occurs in this section, the provisions shall apply to all patient gas/vacuum systems. Wherever the name of a specific gas occurs, the provision applies only to that gas.

B. Systems shall be complete, including alarm system (including signal wiring), pipe, fittings, valves, gauges, outlets, all necessary accessories and manufacturer's installation supervision. Provide equipment and accessories that are listed and labeled and comply with requirements of NFPA 99.

C. The facility has an existing central bulk oxygen supply system. Provide a capped main with 24 volt pressure switch for alarm where indicated for connection to central supply system.

D. Area Medical Gas Alarm System

1. Provide an area alarm panel at each Nurses' Station for specified systems.
2. Alarm

a. General: Modular in design, easy to service and maintain through replaceable components and circuit boards. Alarm shall operate on low voltage and shall include internal transformers as required. Alarm to monitor line pressures. The alarm shall have self-supervising functions to check for short circuits, broken wires and system faults within internal panel wiring and external wiring to include pressure sensors and switches. A green NORMAL light shall glow for all systems normal. If any monitored line goes high or low, green light shall go out and both an audible warning device shall sound and LINE PRESSURE ABNORMAL red light shall come on. Provide switch to silence warning device; however, LINE PRESSURE ABNORMAL light shall remain on until condition has been corrected. If 2 or more LINE PRESSURE ABNORMAL conditions occur, their condition shall be indicated on alarm until corrected. After all conditions have been corrected, NORMAL light shall glow again. Provide test switch to test all internal circuits, LED indicators and audible warning device.

b. Specific: Modules to include individual displays for each gas, each displaying the input from one pressure sensor. Digital characters shall be one-half inch high or larger for easy visibility. Each display shall include an individual LED signal indicator which will illuminate when the alarm is active. Each signal shall be clearly marked by color and by name for the service monitored, and shall clearly show units of measure. Alarms using a single shared digital display shall not be acceptable. Input signals shall be provided by sensors mounted within the alarm panel or in a zone valve box. Alarm sensors shall not be concealed above ceiling. Provide 1/4 inch pilot lines to alarm panels for each gas unless valve box mounted sensors are used. Alarm shall be UL and CSA listed along with each switch and sensor intended for use with the alarm panel.

c. Digital liquid and crystal display panels with a minimum 10 inch screen capable of indicating up to 7 local signals or 8 remote signals may be provided in lieu of modular LED readout type units.

3. Rough-in Box: Box shall be painted 16 gauge steel, provided with adjustable flanges for plaster thickness adjustment. Rough-in shall contain 115 volt power supply, knockouts for pilot piping, connections to signal and main power wires and all necessary interconnection terminals. Power supply shall be enclosed separately from all low voltage signal wiring.
4. Nurse audible alarms must be chime type.

E. Pressure Switches/Sensors for Alarms

1. General: All switches or sensors shall be internally clean for oxygen service and capped or plugged to prevent the entry of foreign matter. Switches and sensors shall be mounted to the pipeline with gas specific DISS check valves for easy removal during calibration or repair.
2. Switches: All wetted surfaces shall be copper, stainless steel, brass or bronze. Inlet fittings shall be of 1/4 inch NPT female. Housings shall be NEMA 1 or better. Switches

shall provide normally closed contacts. Tubing from switch to panel to be as required by switch manufacturer.

3. High pressure switches (100 psig or greater) shall have an adjustable range from 0 to 250 psig, adjustable differential of 3 psig to 30 psig and maximum pressure rating of 900 psig. The switch shall have pressure adjustment, differential adjustment and range indicator located inside a protective cover for ease of access and reading when the cover is removed.
4. Low pressure switches (less than 100 psig) shall contain two pressure switches within one housing, each with an adjustable range from 4 psig to 100 psig. Pressure adjustments shall be visible without disassembly of the switch. Removal of a protective cover is required for adjustment. Low pressure switches shall be prewired with six (6) inch lengths of color coded wire for connection to the alarm.
5. Vacuum switches shall have an adjustable range from 30 inches Hg. vacuum to 10 psig pressure, adjustable differential of .8 to 8 inches Hg. vacuum. The switch shall have pressure adjustment, differential adjustment and range indicator located inside a protective cover for ease of access and reading when the cover is removed.
6. Pressure Sensors: Shall be self-contained, located in the area alarm panel or located in the zone valve box and wired to the alarm panel with no more than two signal wires. Sensors shall not be located above the ceiling. Sensors shall derive power from the alarm panel and shall not require separate power supplies. Sensors shall be of a design which permits attachment to the piping without requiring other support. Signal wire to be shielded type or as required by sensor manufacturer. Signal wire to be run in EMT conduit.

F. Valve Boxes: 18 gauge steel with baked enamel finish, complete with gauges, designed for recessed piping or exposed piping as required with removable transparent window for access to the valve. Label box front: "CAUTION: MEDICAL GAS VALVES, CLOSE ONLY IN CASE OF EMERGENCY", with instruction for removing window. Label shall be color coded for gas identification and indicate rooms controlled by valve.

1. Valves in boxes shall be factory assembled, pressure tested, cleaned capped and rigidly mounted to backbox.
2. Recessed boxes shall have field adjustable trim plate designed to accommodate varying wall finish thickness.
3. Contractor shall have the option of furnishing zone valve boxes with integral pressure sensors, in lieu of pressure sensors mounted in area alarm panels.

G. Service Outlets - Wall Type

1. Provide wall outlets, single unit or multiple unit type as indicated, complete with die-cast chrome plated cover plate and brushed stainless steel finish plate, bearing UL label, designed for recessed piping or exposed piping as required.
2. Outlet completely assembled and pressure tested and cleaned for oxygen service at factory, furnished with self-sealing dust plugs and protective covering to prevent plaster, dust, or other foreign matter from contaminating internal parts of unit during installation. Include both a primary and secondary check as required by NFPA; both checks shall seal when secondary equipment is not attached. Outlets completely serviceable from front, including removal of secondary check and inlet filter screen, without use of special tools, safety-keyed for proper gas service and provide permanently affixed, color-coded identifying nameplate to prevent interchangeability of secondary equipment.

3. Design outlets so that attachment or removal of equipment can be a one-handed operation and release mechanism will not release attached equipment upon inadvertent pushing or bumping.
4. House recessed outlets in an outlet box furnished by outlet manufacturer. Type K copper inlet tubing swedged at the end for connection to service line. Design outlets for accommodating variations in construction and to be completely flush with finishing cover plate.
5. House outlets for surface mounting in a No. 4 finish stainless steel coated surface mounted type box securely fastened to wall, without protrusions beyond stainless steel finish cover plate.
6. Outlets for mounting in lighting consoles shall be self-sealing requiring no dust cap or cover.
7. Provide outlets for vacuum service with brackets and slides for vacuum bottles.
8. Outlet connections shall be of the type matching the facility standard (refer to equipment schedule). Nitrogen outlet connections shall be D.I.S.S. type only.

H. Service Outlets - Ceiling Type

1. Provide ceiling service outlets of single unit type or multiple unit type as indicated, complete with color-coded conductive high pressure hose assembly for each gas service ending in a safety-keyed D.I.S.S. outlet complying generally with above specifications for wall service outlets. Provide nitrogen system outlets with a wall-mounted control panel containing a pressure regulator assembly, and pressure gauge for controlling the discharge pressure.
2. Provide hose retractors and set length of hose assembly so that when fully extended, quick coupler will be approximately 5 feet, 2 inches above floor, and shall retract a minimum of 16 inches when released from fully extended position. Valve type shall be provided meeting facility standard or as indicated in equipment schedule.

I. Nitrogen Outlet Control Panel

1. Provide recessed nitrogen control panel where shown, constructed of 18 gauge steel with protective cover and flange for anchoring to wall, cleaned and lubricated with a lubricant suitable for use with nitrogen and labeled appropriately. Cover plate to be stainless steel with No. 4 finish.
2. The following components are to be factory mounted to a steel support bracket as a manifold and tested before installation in rough-in assembly:

    a. Line pressure regulator, 5-180 psig regulating range, self-relieving type with Buna-N Seals and reinforced rubber diaphragm and chrome plated "Tee" handle for pressure adjustment.
    b. Two 0-300 psig pressure gauges for monitoring the gas supply line and outlet line pressure.

3. Ball type service valve suitable for 300 psig working pressure with seats and seals of Teflon material.
4. Outlet valve compatible with male stem connector provided on pneumatic instruments.

2.3 PIPE AND FITTINGS

A. General

1. Pipe and fitting materials and joint types are specified in the following "Piping Class" paragraphs. Application material and joint type which will be permitted for specific services are specified hereinafter in the Article titled "Piping System Requirements". Where more than one Piping Class is listed under "Piping System Requirements" for a service, use any of listed classes, unless otherwise specified or indicated, but systems' materials must be consistent throughout the work.
2. Pipe and fittings shall conform to the latest issue of the standards referred to hereinafter. Each length of pipe and each fitting shall be marked with the manufacturer's name brand and specification code designation to which it belongs.

B. Piping Class CU4

ITEM	LIMITS	DESCRIPTION
*PIPE	1/8 to 3 inch Pressures 185 psi and higher with pipe sizes 4 inch and larger	ASTM B 819 Copper tubing, Type L, hard temper ASTM B 819 Copper tubing, Type K, hard temper
JOINTS	All sizes	Brazed with Copper phosphorous or Copper phosphorous silver brazing alloy with high-melting point (at least 1000 deg F.) brazing metal. Joints shall be continuously purged with Nitrogen NF.
*FITTINGS	All sizes	Wrought copper and copper alloy only, cast and flared fittings are prohibited.
*ADAPTERS	All sizes	Tinned cast bronze for equipment provided with threaded connections.
		*Pipe and fittings shall be especially prepared by the manufacturer for oxygen and other medical gas service and shall be so marked.

Reference Standards

1. Copper Tubing: ASTM B 819 for medical gas services.
2. Soldered Fittings for Copper Tubing: Wrought copper ANSI B16.22.
3. Cast Bronze Threaded Fittings: ANSI B16.15, Classes 125 and 250 psig.

2.4 PIPING SYSTEM REQUIREMENTS

Service	Valve Type/Class	Pipe Class
Anesthesia Scavenging System	MGV	CU4
Compressed Air, Medical Service Including Air Intake	MGV	CU4
Nitrogen, High Pressure	MGV	CU4
Nitrous Oxide	MGV	CU4
Oxygen, Above Ground	MGV	CU4
Vacuum, Medical Service	MGV	CU4

2.5 VALVES

A. General

1. Valves are specified by Valve Type and, for some services, several valve types are grouped by "Valve Class" in various sections of Division 15. Application is stated in the "Piping System Requirements". Where more than one Valve Type or Valve Class is listed for a service, use any of the listed Types or Classes, unless otherwise specified or indicated, but selection must be consistent throughout the work.
2. It shall be Contractor's responsibility to coordinate the work for all sections of Division 15 to assure that all general service valves throughout the work of Division 15 are of the same manufacture and type and that all valves of the same type number/identification throughout the work of Division 15 are of the same manufacture.
3. Valve packing shall not contain asbestos.
4. Bronze Valves: Construct body of ASTM B 62 for Classes 125 and 150, ASTM B 61 for Classes 200 and 300, copper-silicon bronze stem.
5. Iron Valves: Construct body of ASTM A 126, Class B copper-silicon bronze stem.

B. Refer to Section 22 05 00 for specifications for basic valve types not specified in this section.

C. Type MGV, Medical Gas System Valves

1. Valves especially prepared for oxygen service by the manufacturer and so marked.
2. Shutoff Valves: Bronzed-bodied, 3-piece bolted union type ball valves with thread end, solder joints or tubing extensions as required. Buna-N or Teflon stem seals, dual seal blowoutproof stem, chrome-plated bronze ball which seals in both directions. Designed for working pressure up to 300 psi. Valves designed so that only a quarter turn of lever-type handle is necessary between open and closed positions.
3. Check Valves: Cast bronze body, straight through design, ball type check, spring loaded, mating with a cone seat, vibration free. Designed to a working pressure up to 300 psi.
4. Valves shall have Type K tubing extensions factory brazed to valve flanges for connection to the pipeline. Valves in boxes shall be factory preassembled, pressure tested, cleaned, capped and rigidly mounted to backbox.

D. Valve Classes

1. Valve Class VC-4

SERVICE	LIMITS	ALLOWABLE VALVE TYPES
SHUTOFF	Copper Tubing	V4 gate, V8a, V9
	Steel Pipe	V4 gate, V8a, V9
THROTTLING (BYPASS)	Copper Tubing	V4 globe, V9
	Steel Pipe	V4 globe, V9
BALANCING		V6a, V6b, V7, V8a*

CHECK	Copper Tubing	V1 swing check or V14 at storm water or sanitary pump discharge, V1 & V4 elsewhere
	Steel Pipe	V2 swing check or V14 at storm water or sanitary pump discharge, V2 & V4 elsewhere
*Not allowed for pump discharge balancing service.		

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. General

1. Refer to and comply with Section 220500 for basic requirements.
2. Refer to Section 220548 for vibration isolation and seismic restraints, penetration seals and the like.

B. Manufacturers' Supervision/Inspection: Contractor shall be fully responsible for properly making arrangements for and coordinating with the manufacturer to provide the specified manufacturer's supervision/inspection services and manufacturer's written certification as specified in Part 1 of this section, and shall at his own expense make any corrections/modifications to his installation work as required by the manufacturer.

3.2 COMPRESSED AIR SYSTEM, MEDICAL

A. Provide system complete with pipe, fittings, valves, gauges, outlets, air compressors, receiver and controls in accordance with manufacturer's instructions and NFPA 99, except that all joints shall be brazed. Soldered joints are not acceptable.

B. Extend system from existing compressed air mains.

C. Installation of compressed air piping, shutoff valves, alarm panels and other accessories shall be identical with that specified under "Medical Gas Systems".

3.3 ELECTRICAL WORK

A. Refer to Section 22 05 13 for general requirements.

B. Power wiring will be provided under Division 26, Electrical, to the following:

1. Area Medical Alarm Panels

C. Signal wiring will be provided under Division 22, Plumbing, to the following:

1. Area medical gas alarm panels to pipeline sensors/switches.

3.4 MEDICAL GAS SYSTEMS - CARBON DIOXIDE, OXYGEN, NITROUS OXIDE AND NITROGEN SYSTEMS

A. Install system under direction and supervision of equipment manufacturer's representative. Installation of systems including piping, valves and fittings, to be in accordance with recommendations and requirements of applicable sections of NFPA 99 unless specific requirements are listed herein.

B. Extend new oxygen, nitrous oxide and nitrogen piping from existing mains.

C. Ground piping to water supply system to reduce possibility of static electric charges.

D. Piping, valves and fittings shall be specially cleaned for oxygen service and packaged by the manufacturer. On-site cleaning is prohibited except for recleaning surfaces in the immediate vicinity of the joints prior to brazing. Material that has not been properly stored and protected that has become contaminated shall not be installed and immediately removed from the site.

E. Brazing procedures and brazer performance shall be in accordance with NFPA 99.

F. Label or paint piping, concealed and exposed, to indicate its content at minimum of 20 foot intervals along the pipe and where it enters or leaves a partition. Metal tags, stenciling or adhesive markers may be used if affixed so as not to be readily removable. Use bright green to indicate oxygen piping, medium blue to indicate nitrous oxide piping, yellow to indicate medical air piping, black to indicate nitrogen piping and white to indicate vacuum piping.

G. Label all valve boxes designating areas or rooms (by numbers) being served.

H. Provide a printed schedule in frame and glass cover giving each valve number with location and section which it controls. Locate frame as directed.

I. Install area alarm panel.

1. Area Alarm System: Contractor for this section shall install area alarm panel[s] with pressure sensors for each gas at the location specified. Alarm panels serve specific departments, locations, areas, etc., and are to monitor all zone control valves in that area or department. Alarm panel modules shall be labeled for the specific areas they control. Sensors are to be located as noted on drawings or delineated in NFPA 99.
2. Tubing between panels and switches to be installed by Contractor for this section. Signal wiring between panels and switches/sensors to be installed by contractor for this section. Signal wiring to be installed in conduit per NFPA 70.

3.5 PIPING CONNECTIONS

A. Refer to Section 22 05 00 for basic requirements.

B. Joints in Medical Gas and Vacuum (Pipe Class CU4): Comply with the requirements of NFPA 99 for medical gas and vacuum. Join with silver brazing alloy or similar high melting point (at least 1000° F.) brazing metal. Use oil free nitrogen purge while brazing medical gas and vacuum. Flux may be used only in the joining of dissimilar metals. Flared and compression joints, soldered joints and cast brass fittings are prohibited.

3.6 TESTING OF PIPING SYSTEMS

A. Refer to Testing of Piping Systems, General in Section 22 05 00.

B. Medical Gas Systems (including Medical Air and Vacuum): Refer to previous article in Part 3 of this section.

3.7 TESTING AND CERTIFICATION OF MEDICAL GAS SYSTEMS

A. The Medical Gas Systems, whether new, renovated or repaired, including all source equipment, valving, alarms, and use point outlets shall be evaluated and certified for mechanical and therapeutic function as defined in NFPA 99. This testing shall be performed first by the installing contractor and then by an agency independent of the Contractor or their suppliers. The Agency shall specialize in medical facilities and be able to demonstrate experience and expertise in medical gas installations.

B. The following tests are to be performed by the installing contractor before the closing of walls. (Refer to NFPA 99 for detailed descriptions on how the tests are to be performed.)

1. Pressure testing of each section of the piping system
2. Blowdown of the piping systems
3. 24 hour standing pressure test of each system
4. Piping system purging to remove particulate matter
5. Piping systems cross-connection tests.

C. The following tests are to be performed by the independent agency after the closing of walls and the testing by the installing contractor. (Refer to NFPA 99 for detailed descriptions on how the tests are to be performed.) The agency will provide documentation of the following as a minimum:

1. That all medical gas systems as constructed follow the guidelines of NFPA 99, regarding the placement and applicability of valves, alarms, and source equipment.
2. That no cross connections exist in the pipe line as constructed. Include in documentation the examination of the outflow of each outlet in the oxygen, nitrous oxide, medical air, and vacuum systems, following a mechanical cross connect procedure as specified by NFPA 99. Each outlet outflow shall be examined with an appropriate analyzer and the concentrations documented.
    a. Outlets immediately upstream or downstream of existing medical gas systems from wherever a breach occurs shall be analyzed as listed for new outlets. (All existing piping systems tested with nitrogen must be analyzed as listed for new systems.)
3. That all outlets are delivering gas at a pressure and flow as defined in NFPA 99.
4. That all pipelines have been tested, purged and purity of piping systems verified.
5. That all outlets are functional.
6. That source gas is as pure as required by applicable CGA/USPHS specifications and NFPA 99 for breathing gas. Samples taken from such points as agreed upon by the facility and the agency. In no case shall the number of samplings be fewer than two, one from source and one from such use point as will provide that gas has traversed the

greatest length of pipeline. Evaluate samples against CGA/USPHS requirements for human use and compare to one another.

7. That all reserve source equipment and its control equipment is in place and is operational.
8. Location and functioning of all valves and the control zones without regard to plans. Compare this documentation to the as-built plans, and report all discrepancies between the actual installation and the plans to the Architect and Owner.
9. That all alarms are functioning and are set in accordance with NFPA 99. The surveillance areas of each shall be documented and compared as specified in item 8.
10. That all station outlets, shutoff valves and alarm panels are correctly labeled.
11. That medical air is dry and free of contaminants. Concentrations to be within limits listed in NFPA 99. Take dewpoint readings at source and most distant outlet of each lateral branch. Indicate temperatures and pressures affecting the dryness. Medical air compressor system to be tested in accordance with NFPA 99.
12. Where separate anesthesia gas evacuation outlets are provided, the evacuation system shall be included in all mechanical examinations (2, 3, 5, 7, 8 and 9 above), and separation from other systems shall be documented.

D. The medical gas verification test shall be provided by an independent certifier who complies with ASSE 6030 Professional Qualifications Standard for Medical Gas Verifiers, has a minimum 5 years experience certifying medical gas systems and has been pre-approved by the Owner. Certifier shall provide documentation, containing all of the above information as well as the certification upon successful completion of all specified tests. Contractor will not be released from his contractual obligation until certification is obtained. Submit copies of the certification to Architect, installer, facility and authority having jurisdiction. Certification and documentation shall bear the seal of a Registered Engineer licensed to practice in California.

3.8 VACUUM SYSTEM, MEDICAL

A. Extend new system from existing vacuum mains.

B. Installation of vacuum piping, shutoff valves, alarm panels and other accessories shall be identical with that specified under "Medical Gas Systems".

END OF SECTION 22 60 00

SECTION 23 05 00 – COMMON MATERIALS AND METHODS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section is intended to describe the common materials and installation methods of the mechanical work and it applies in general to all other Sections under Division 23.

B. Due to the small scale of the drawings, all work required is not shown on the floor plans and certain work is shown on flow diagrams, riser diagrams and details. Work of Division 23 shall include all required work shown on plans, riser diagrams, flow diagrams and details.

C. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems
2. Transition fittings
3. Dielectric fittings
4. Mechanical sleeve seals
5. Sleeves
6. Escutcheons
7. Grout
8. HVAC demolition
9. Equipment installation requirements common to equipment sections
10. Painting and finishing
11. Concrete bases
12. Hangers and supports for HVAC system piping and equipment
13. Identification for HVAC Piping and equipment

1.3 DEFINITIONS

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

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

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 REFERENCES

A. Provide work in accordance with all applicable international, state and local, codes, rules, regulations, and standards, including but not limited to, requirements of the following:

1. ASME/ANSI B31: Code for Pressure Piping
2. ASME Boiler and Pressure Vessel Codes
3. AWS D1.1: Structural Welding Code-Steel
4. MSS SP58: Pipe Hangers and Supports – Materials, Design, and Manufacturers
5. MSS SP69: Pipe Hangers and Supports – Selection and Application except spacing for hangers
6. ANSI A13.1: Scheme for Identification of Piping Systems
7. Applicable NFPA Codes and Standards
8. 2012 ICC Codes
9. 2014 FGI guidelines for Design and Construction of Hospitals & Outpatient Facilities

1.5 SUBMITTALS

A. Provide Product List of factory fabricated items, in accordance with Section 01 60 00 "Product Requirements", including name of proposed manufacturer, for all products specified in various sections of Division 23.

B. Provide submittals in accordance with Section 01 33 00 "Submittal Procedures" in sufficient detail to verify full compliance with the requirements of the Contract Documents.

C. Product Data: Provide for each type of factory-fabricated product indicated.

D. Welding certificates.

1.6 WARRANTY AND CONTRACT CLOSEOUT

A. Comply with warranty and contract closeout requirements specified in Division 00.

B. Provide Special Warranties and/or warranty service in accordance with Section 01 60 00 "Product Requirements" where specified in the various sections of Division 23.

C. Provide manufacturer's certificates of supervision and startup service as specified in the various sections of Division 23.

D. Provide testing and cleaning reports. Indicate dates of testing and cleaning operations, procedures used and results obtained for each system. Reports shall be certified as complete.

E. Provide instructions and demonstration to the Owner's representative for all equipment and systems installed under Division 23. Instruction and demonstration shall be appropriate for the size and complexity of the installed system.

F. Include information for all products specified in the operation and maintenance manual.

1.7 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. Use welders fully qualified and licensed by the state authorities.

C. The specifications for certain products and alternative materials may appear in more than one section of Division 23. Work of Division 23 shall be coordinated for all sections of Division 23 to assure that where two or more items of any given product are furnished under Division 23 that they are of the same manufacturer and type and that alternative materials is consistent throughout the work of Division 23.

D. Except for spacing of hangers, provide hangers and supports in accordance with the latest issue of Manufacturer's Standardization Society (MSS) Specifications SP 58 and 69.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle all material and equipment in accordance with manufacturer's instructions and recommendations. Such instructions and recommendations are hereby made part of these specifications.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Deliver products and equipment properly labeled and tagged. Maintain products in original shipping containers and store in a dry area until ready for installation.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.9 COORDINATION

A. The Mechanical systems are indicated on the Mechanical Drawings. Certain pertinent information and details involving the installation of Mechanical work appear on Architectural, Structural, Plumbing and Electrical Drawings. Become familiar with all Drawings and incorporate all pertinent requirements.

B. Drawings are diagrammatic and indicate general arrangement of systems and requirements of the Mechanical work. Do not scale the Drawings to obtain dimensional requirements. Exact locations of equipment must be coordinated and obtained prior to starting the work.

C. Arrange for pipe spaces, chases, slots, duct shafts and openings in building structure during progress of construction, to allow for HVAC installations.

D. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

E. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Coordinate installation of identification labels with locations of access panels and doors.

F. Coordinate scheduling, sequencing, movement and positioning of large equipment into the building during construction.

G. Coordinate installation of identification devices with completion of covering and painting of surfaces where identification devices are to be applied.

H. Install identification devices prior to installation of ceilings and similar concealment.

1.10 SEISMIC REQUIREMENTS

A. Seismic Design

1. All new and existing Mechanical systems (equipment, piping and ductwork) shall be provided with seismic restraints in accordance with the requirements of the applicable building code and site specific seismic design parameters and Division 23 Section "Vibration Isolation and Seismic Restraints for HVAC Systems".
2. Refer to Structural Drawings & Division 01 for seismic criteria to be used for this project.
3. Use a component Importance Factor, I_p, of 1.5 for all life safety systems required to function during and after an earthquake; including, but not limited to:

    a. Hospital heating and air conditioning systems required to maintain normal ambient temperature.
    b. Automated smoke control systems and/or smoke evacuation systems.

4. Use a component Importance Factor, I_p, of 1.5 for all components that contain hazardous material including, but not limited to:

    a. Hospital isolation room exhaust
    b. Biohazard exhaust
    c. Gas piping
    d. Fuel oil piping
    e. Steam piping

5. Use a component Importance Factor, I_p, of 1.5 for all systems and components required for continuous operation of the facility or whose failure could impair the continued operation of the building, including:

a. Ductwork and piping
b. Suspended equipment

6. Except as noted otherwise herein, use an Importance Factor, I_p, of 1.0 for all other components.
7. Employ a Professional Engineer registered in the jurisdiction for which the project is located to design all restraints necessary to meet the seismic requirements. Said Engineer shall sign and seal all drawings and calculations prepared for this purpose.
8. Prior to first Application for Payment, provide a complete listing of all components and elements that are to be seismically restrained and/or braced.
9. It is the entire responsibility of the equipment manufacturer to design their equipment so that the strength and anchorage of the components of the equipment exceeds the force level used to restrain and anchor equipment itself to the supporting structure. Factory manufactured and/or field or shop fabricated equipment shall be designed to safely accept and resist, at its points of anchorage or suspension without failure or permanent displacement of the equipment, earthquake generated external forces required by the code.
10. The preparation and submittal of product data and shop drawings to the Architect for review shall constitute a representation by the manufacturer, contractor and vendor that all components comply with the above requirements.
11. The functional and physical interrelationship of components and their effect on each other shall be installed so that failure of an essential or nonessential architectural, mechanical, electrical component shall not cause the failure of nearby essential architectural, mechanical, or electrical components.

B. Seismic Design

1. Installation of all new and existing mechanical systems (equipment, piping and ductwork) to be in accordance with seismic requirements of the applicable building code and site specific seismic design parameters, considering exemptions where applicable.
2. Refer to structural drawings and Division 01 "Summary of Work" for seismic criteria to be used on project.

1.11 ENERGY PERFORMANCE CRITERIA

A. All equipment provided under Division 23 shall meet the requirements of the International, or State, Energy Code, ASHRAE Standard 90 or the latest issue of the Standards for Equipment in the National Energy Policy Act (NEPA), whichever is more stringent.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. In other Part 2 articles of various sections of Division 23 where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2. Unless otherwise noted, substitutions of specified manufacturers shall comply with the requirements of Division 01.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

B. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150-psig (1035-kPa) minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Separate companion flanges and steel bolts and nuts shall have 150-psig (1035-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.6 ESCUTCHEONS

A. General: Manufactured wall and ceiling escutcheons and floor plates, with an inside diameter to closely fit around pipe, tube, and insulation of insulated piping and an outside diameter that completely covers opening.

B. One piece construction on exposed piping in finished areas. Elsewhere, split pattern with setscrew. Provide deep pattern type where required to conceal protruding fittings and sleeve.

C. Provide brushed brass escutcheons, except provide polished chromium plated escutcheons on pipes passing through walls, floors or ceilings wherever such pipes are exposed to view.

2.7 HANGERS AND SUPPORTS

A. Acceptable Manufacturers

1. Other Than Roof Supports

   a. B-Line Systems, Inc.
   b. Grinnell Company
   c. National Pipe Hangers
   d. Penn Construction Industries
   e. Other approved United States manufacturer whose products comply with the referenced standards

B. Reference Standards

1. ASTM A 36 - Specification for Structural Steel
2. ASTM A 123 - Zinc (Hot-Dip Galvanized Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Bars, and Strip)
3. ASTM A 653 G90 - Specification for Steel Sheet, Zinc Coated by the Hot-Dip Process
4. ASTM B 633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel
5. AWS D1.1 - Structural Welding Code - Steel
6. MSS SP58 - Manufacturer's Standardization Society: Pipe Hangers and Supports - Materials, Design and Manufacture
7. MSS SP69 - Manufacturer's Standardization Society: Pipe Hangers and Supports - Selection and Application
8. NFPA 13 - Standard for the Installation of sprinkler Systems

C. Quality Assurance

1. Steel pipe hangers and supports shall have the manufacturer's name, part number and applicable size stamped in the part itself for identification.
2. Hangers and supports shall be designed and manufactured in conformance with MSS SP58.

D. General

1. Except for spacing of the hangers, design and fabrication of pipe hangers, supports and welding attachments shall conform to ANSI B31.9 or B31.1 as applicable.
2. Except for spacing of the hangers, hanger types and supports for bare and covered pipe shall conform to MSS SP69 for the temperature range except that only flat wide band hangers shall be used for hangers installed outside of insulation and plastic pipe.
3. Except for spacing of pipe hangers and elsewhere as otherwise indicated, horizontal and vertical piping attachment shall conform to the more stringent of this specification or MSS SP58 or MSS SP69. Continuous inserts and expansion bolts may be used.
4. All ferrous hangers, supports and hardware located outdoors shall be hot dip galvanized after fabrication per ASTM A 123.
5. Hangers and clamps for support of bare copper piping shall be coated with copper colored (for identification) baked on epoxy paint. Use additional PVC coating of the epoxy painted hangers where necessary.
6. Provide suitable chromium plated brass supports for chromium plated pipe with exposed heads of bolts and screws chromium plated.

7. Hangers other than described above shall be zinc plated in accordance with ASTM B 633 or shall have an electrodeposited epoxy finish.
8. Strut channels shall be pregalvanized in accordance with ASTM A 653 G90 or shall have an electrodeposited finish.
9. All hangers and supports shall have some form of adjustment available after installation.

E. Inserts

1. Inserts: Malleable iron case or galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms.
2. Size inserts to suit threaded hanger rods.

F. Pipe Hangers and Supports:

1. Hangers for Pipe Sizes to 1-1/2 Inch (DN 40): Adjustable carbon steel ring or clevis.
2. Hangers for Hot or Cold Pipe Sizes 2 Inches to 4 Inches (DN 50 to DN 100) and Cold Pipe Sizes 6 Inches (DN 150) and Over: Adjustable carbon steel clevis.
3. Multiple or Trapeze Hangers: Factory-enameled steel channels with welded spacers and hanger rods or 12 gauge (2.7 mm) rolled formed ASTM A 570 Grade 33 structural quality steel channels (strut), cast iron roll and stand for hot pipe sizes 6 inches (DN 150) and over. Cross section suitable for span and loading. Suspension by outside hanger rods sized for total load on trapeze.
4. Wall Support for Pipe Sizes to 3 Inches (DN 80): Carbon steel hook.
5. Vertical Support: Steel riser clamp.
6. Floor Support for Hot Pipe Sizes to 4 Inches (DN 100) and All Cold Pipe Sizes: Adjustable pipe saddle and pipe nipple attached to steel base stand, and concrete pier or steel support.
7. Design hangers to impede disengagement by the movement of supported pipe. Provide spring and neoprene hangers as required.

G. Beam Clamps: Forged steel C-clamps shall include retaining strap, locking nut or other device for nonslip attachment, except LOCKING NUT NOT ALLOWED for project requiring seismic restraints.

H. Hanger Rod: Steel hanger rod zinc plated per ASTM B 633.

2.8 THERMOMETERS

A. Acceptable Manufacturers

1. Trerice
2. Taylor Instrument Company
3. U.S. Gauge
4. Weksler
5. Weiss

B. Dial Thermometer: Bi-metal type, case assembly of type 304 stainless steel, moisture proof heavy glass face, gasketed and hermetically sealed. Stem and fixed threaded connection of stainless steel, all welded construction. Provide 5 inch dial of heavy gauge aluminum with

white matte finish, black graduation lines and numerals. Provide separable sockets of depth suitable for pipe size in which installed.

C. Tube Thermometer: ASTM E 1, liquid in place thermometer. Cast aluminum case, black baked epoxy enamel finish, 9 inch minimum liquid filled tube, brass stem, adjustable angle type with locking device and with brass union type separable socket. Socket length to suit installation. Mercury filled thermometer not allowed.

D. Select range of thermometer to indicate normal operating temperatures at midpoint of scale. Scale division of 1 degree F for cold service and 2 degree F for hot service.

E. Install wells with stem extending to center of pipe. Fill wells with oil or graphite and secure caps.

2.9 PRESSURE GAUGES

A. Acceptable Manufacturers

1. Trerice
2. Taylor Instrument Company
3. U.S. Gauge
4. Weksler
5. Weiss

B. ASTM B 40.1, Grade A phosphor bronze seamless Bourdon spring type with white face, black numerals, 4-1/2 inch cast aluminum case, black baked epoxy enamel finish, brass bronze bushed movement and brass socket. Select range of gauge to indicate normal operating pressure of system at midpoint of scale.

C. Provide 1/4 inch brass coil siphon for steam gauge. For liquid gauge, provide brass snubber of material suitable for system fluid. Provide with needle valve.

2.10 IDENTIFICATION DEVICES AND LABELS

A. General

1. Products specified are manufacturer's standard products of categories and types required for each application as referenced in Part 3 of this section and elsewhere on the drawings or in Division 23 specifications. Where more than single type is specified for listed application, selection is Contractor's option, but provide single selection for each product category.
2. Products shall comply with requirements of ANSI A13.1 and OSHA where applicable.

B. Stencils: Standard stencils, prepared with letter sizes conforming to recommendations of ANSI A13.1. Minimum letter height is 1-1/4 inches for ducts and 3/4 inch for access door signs and similar operational instructions.

1. Stencil Paint: Exterior, oil-based alkyd gloss black enamel, except as otherwise indicated. Paint may be in pressurized spray-can form.

2. Identification Paint: Exterior, oil-based alkyd enamel in colors according to ANSI A13.1, except as otherwise indicated.

C. Snap-On Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid snap-on, color-coded pipe markers conforming to ANSI A13.1.

D. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive vinyl pipe markers, with permanent adhesive conforming to ANSI A13.1.

E. Pipes/Insulation Smaller Than 6 Inches (DN 150): Full-band pipe markers, extending 360 degrees around pipe/insulation at each location.

F. Arrows: Either integrally with piping system service lettering (to accommodate both directions), or as separate unit, on each pipe marker to indicate direction of flow.

G. Plastic Duct Markers: Manufacturer's standard laminated plastic, duct markers in the following color code:

1. Green: Cold air.
2. Yellow: Hot air.
3. Yellow/Green: Supply air.
4. Blue: Exhaust, outside, return, and mixed air.
5. For hazardous materials exhausts, use colors and designs recommended by ASME A13.1.
6. Terminology: Include direction of air flow, duct service, system identification.

H. Plastic Tape: Manufacturer's standard color-coded, pressure- sensitive, self-adhesive, vinyl tape, at least 3 mils thick. Width 1-1/2 inches wide on pipes with outside diameters (including insulation) less than 6 inches (DN 150); 2-1/2 inches wide for larger pipes. Color shall comply with ANSI A13.1 unless otherwise indicated.

I. Valve Tags: Stamped or engraved brass with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Provide a hole for fastener. Brass wire-link chain, beaded chain, or S-hook fasteners.

J. Access Panel Markers: 1/16 inch thick engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed device. Provide center hole for attachment.

K. Valve Schedule Frames: Glazed display frame, with screws for removable mounting on masonry walls for each page of valve schedule. Polished hardwood or extruded aluminum frame.

L. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening. 1/16 inch thick for units up to 20 square inches (0.013 square meters) or 8 inch length, 1/8 inch thick for larger units. Self-tapping stainless steel screws or contact-type permanent adhesive.

M. Plasticized Tags: Preprinted accident-prevention tags, of plasticized card stock. Size approximately 3-1/4 by 5-5/8 inches. Brass grommets and wire fasteners.

N. Nomenclature: Large-size wording such as "DANGER," "CAUTION," or "DO NOT OPERATE", or as noted on the drawings in the specification.

O. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.

P. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. General

1. Furnish, deliver, erect, connect, and finish in every detail all materials, equipment and accessories required for the Work.
2. Include in the work and in the bid minor details not usually shown or specified, but manifestly necessary for the proper installation and operation of the various systems, the same as if specified or shown.
3. If any departures from the Contract Documents are deemed necessary, submit details of such departure and the reasons therefore to the Architect for approval.
4. Be responsible to request clarification from the Architect on any conflicts represented between the drawings and specifications.
5. Adequately guard all exposed moving parts of equipment, such that contact by operating personnel will not cause personal damage or injury.

B. Layout and Coordination With Other Trades

1. Layout Work from building and property lines and benchmarks provided, verify, and be responsible for the correctness of all measurements in connection with the Work. Any change made in major overall dimensions shown which affect the physical size, shape, or location of any part of the Work, whether due to field check or changes due to use of equipment of a manufacturer other than that used as basis of design shall cause no interference with other Work.
2. Examine the Drawings of other trades, cooperate and coordinate with other trades to insure that the Work can be installed properly as designed and planned without interference with other work or delay. Where interferences may occur and departures from the arrangements shown are required, consult with other trade involved. Come to agreement as to changed locations and elevations. Furnish all necessary templates, patterns, measurements, etc., for installation and for the purpose of making adjoining work conform. Furnish setting plans and shop drawings to other trades as required.
3. Investigate the structural and finish conditions affecting the Work. Offsets, bends or other items required may not be shown on the drawings; provide such offsets or bends as required to meet structural or finish conditions.
4. Coordinate layout with architectural ceilings and lighting layouts and similar work.

5. Coordinate and be responsible for the required clearances in shafts, chases, furred partitions and suspended ceilings. Coordinate and cooperate with the trades responsible for constructing such spaces, together with other trades sharing such spaces, and advise other trades of the requirements of the Work. Immediately submit for review large scale composite Drawings showing space requirements that exceed those shown.
6. Install systems so that they do not interfere with any openings, doors or windows, or with other work, and so as to permit proper access.
7. Install material and equipment as high as possible; at minimum, to clear the top of all doors, windows and other structural openings. Maintain maximum headroom and space conditions in every case. Where headroom or space conditions appear inadequate, notify the Architect before proceeding with the installation.
8. Except where greater clearance is specified or required by applicable codes, rules or regulations, install piping, ductwork, fittings, valves, etc., to provide not less than 1 inch between their finished covering and the structure or adjacent work of any kind. The minimum space between finished hot piping of any kind and adjacent electrical conduit shall be 6 inches.
9. Make reasonable modifications in the layout to provide proper clearances or accessibility, or to prevent conflict with the work of other trades, at no increase in the Contract sum.
10. Prepare large scale composite working drawings, including such section views and details as are necessary to clearly show how the systems are to be installed in relation to the work of other trades. Issue such Drawings to the other trades for coordination of their work. Where such drawings show deviations from the Contract Drawings or conflict with other trades such that reasonable modifications cannot be made, detail and submit such deviation or conflict to the Architect for review.
11. If work is installed before coordinating with other trades so as to cause interference with the work of other trades, or as not to provide proper access for maintenance or repair, make necessary changes to correct the condition at no increase in the Contract sum.
12. For alterations to existing facilities, be fully responsible for coordinating work with all existing conditions. Verify location of existing piping, ductwork and equipment in the field. Relocate or offset new piping and ductwork, and make reasonable modifications to existing piping and ductwork, as required to fit in available space whether or not such relocation of offset is shown on the Drawings.

C. Manufacturer's Instructions and Recommendations

1. Perform the installation, cleaning, testing, calibration and startup of all material and equipment in accordance with the manufacturer's instructions and recommendations. Such instructions and recommendations are hereby made part of the specifications.
2. Should a conflict exist between specifications and manufacturer's instructions, consult with the Architect.

D. Electrical Rooms

1. Do not install any piping, ductwork or equipment in or through an electrical room or similar room containing electrical equipment, other than piping, ductwork or equipment exclusively serving the room or equipment in the room.
2. If there is a conflict between the above requirement and the Drawings, the above shall govern. If reasonable modifications cannot be made to accommodate this requirement, obtain instructions from the Architect before proceeding with the work.

E. Painting

1. Except where specified otherwise in Division 23, Work of Division 09 will provide painting of HVAC systems, equipment and components.
2. Protect all equipment from rust, corrosion, and similar damage by either factory applied or field applied protective coatings.
3. Repair marred and damaged factory painted finishes with manufacturer's touch up paint and application procedures to match original factory finish.

F. Wall and Ceiling Access Doors

1. Access Doors shown on Architectural Drawings will be provided under Division 08.
2. Furnish access doors required for access to concealed dampers, valves, air vents, traps, cleanouts, unions, expansion joints, and other equipment where no other means of access is available. Access doors shall be of adequate size for the service requirements, minimum clear opening of 14 inches by 16 inches.
3. Access doors shall be as specified in Division 08. Coordinate locations of access doors with all trades.

3.2 PENETRATIONS

A. General

1. Coordinate with other trades as to the size and location of openings to be provided in new floors, walls, roofs and ceilings as construction progresses.
2. Do not cut openings in new or existing floors and walls without proper structural reinforcement.
3. Install both piping and seals so as to maintain integrity of seals with expansion and contraction of piping.
4. Catheterization Lab Sealing Requirements:

    a. Seal completely all penetrations of piping, ductwork and conduit through any surface.
    b. Seal completely all penetrations of piping, ductwork and conduit through above ceiling full height partitions.
    c. Seal completely the perimeter of all Mechanical fixtures and devices, including diffusers and grilles, applied to any surface.
    d. Seal completely the perimeter of all access doors or panels in any surface.

B. Sleeves

1. Provide each pipe, duct or conduit passing through a masonry or concrete wall, floor or partition, and elsewhere as indicated, with a sleeve made from standard weight galvanized steel pipe for pipe or conduit and 12 gauge galvanized sheet steel for ducts, with smooth edges, securely and neatly set in place.
2. Select sleeves two pipe sizes larger than any pipe or conduit to accommodate pipe, insulation, and jacketing without touching the sleeve and shall provide minimum of 3/8 inch clearance.
3. Be responsible for the proper location and alignment of all sleeves.
4. Extend wall and partition sleeves through and cut flush with each surface unless otherwise indicated or specified.

5. Place sleeves imbedded in concrete floors or walls in the forms before concrete is poured; sleeves shall have integral water stop flanges, where they are to receive either water tight or hydrostatic seals.

C. Fire Rated Penetrations

1. Provide through-penetration fire-stop sealing system for pipe, duct and conduit penetrations through fire or smoke rated construction. Refer to Division 07 for through-penetration fire stop sealing system.
2. Coordinate with Division 07 to determine requirements for sleeves and clearances.
3. Select duct sleeve sizes to suit requirements of manufacturer of fire and/or smoke dampers.

D. Interior Non-Rated Wall Pipe Penetrations

1. For acoustically treated partitions, and walls between mechanical equipment rooms and occupied spaces, fill annular void at penetration with acoustical sealant.

E. Resilient Penetration Sleeve/Seal

1. Provide resilient penetration sleeve seal for piping and ductwork subject to vibration to prevent transmission to the building structure.
2. Maintain an airtight seal around the penetrating element and prevent rigid contact of the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

F. Floor Pipe Penetrations

1. Provide water stops for new cored openings for piping where such openings are above grade in laboratories, mechanical rooms, penthouses, and pipe chases.
2. Provide water stops for existing pipe floor openings that do not have sleeves extended above the floor.
3. Provide either a sleeve or angle water stop. Sleeve may be used if the fire-stop sealing method selected by Division 07 allows the use of a sleeve, otherwise provide angle water stop.
4. Sleeve Water Stop: Construct of Schedule 40 galvanized steel pipe, length as required for 1 inch above floor and 1 inch below underside of floor. Provide 1 inch by 1 inch by 1/8 inch galvanized angle clips welded to sleeve at 90 degree intervals and securely fastened to underside of floor. Caulk space between floor opening and sleeve water tight with soft setting waterproof silicone sealant.
5. Angle Water Stop: Construct of standard weight pipe 1 inch long welded to a 1/4 inch circular steel base plate ring fastened to floor with expansion anchors. Base plate ring width as required for anchor clearance from edge of cored opening. Seal between base ring and floor and caulk all edges of base ring with waterproof silicone sealant.

3.3 ALTERATIONS OF UTILITIES AND SERVICES

A. Arrange and pay for the relocation, disconnection or removal of existing utilities and services where such utilities and services interfere with new construction. Perform alteration of utilities

and services in accordance with rules, regulations and requirements of the involved utility company as well as regulatory agencies having jurisdiction.

3.4 ALTERATIONS AND CONNECTIONS TO EXISTING FACILITIES

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Make all necessary alterations to existing Division 23 systems as required for removing or for connecting or extending these systems to new work and for revisions in existing work as indicated and as required, whether indicated or not. Match new materials in altered systems with existing materials unless otherwise indicated.

C. Continuity of Existing Services

1. Perform alterations and connections to existing facilities with a minimum of interruption. Where interruption is necessary, prepare a time schedule for shutdown activities, coordinate with Architect, Owner and other trades, and obtain written approval from Owner prior to proceeding with the work. Include work scheduled for off hours, when Owner requires that shutdown and interruption of facilities occur during unoccupied times.
2. Prepare and set notices on services and equipment that are temporarily shut off or disconnected.

D. Provide shutoff valves to isolate new work from existing and temporary or permanent connections to new work as required for proper testing and cleaning of new work.

E. All relocations of existing work shall be accomplished using new materials and accessories unless specifically noted otherwise.

F. Where equipment, ductwork and piping is removed or disconnected under Division 23, perform the work in such a manner that no damage is done to the structure or remaining portions of the existing systems. Do not under any circumstance place stress on existing pipe and fittings that are to be reused. Be fully responsible for and repair, at no additional expense to the Owner, any leaks developing in existing piping due to failure to take proper precautions when making alterations.

G. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Do not abandon any piping in place unless specifically noted to do so. Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Do not abandon any ductwork in place unless specifically noted to do so. Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.

6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
8. All materials and equipment removed or disconnected by Division 23, which is not to be reused or delivered to Owner, shall be removed from the premises. Provide owner first right of refusal of equipment prior to removal from site.

H. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

I. Remove all piping, ductwork and equipment hangers and supports.

J. Cap tight unused connection at mains and risers behind finished surfaces.

3.5 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install all piping in accordance with best practices of trade and latest code requirements. Locate groups of pipes parallel to each other, spaced to permit valve servicing. Use uniform system materials throughout building.

D. Install components having pressure rating equal to or greater than system operating pressure.

E. Keep all piping as high as possible, consistent with proper pitch, to maintain maximum headroom. Cut piping accurately to measurements established at building, work into place without springing, forcing or cutting of the building structure, and install as directly as possible without sags between connecting points parallel with or at right angles to building construction, except as required to obtain pitch.

F. Pitch all systems for proper venting at high points and to drain at low points where the systems can be completely emptied. Install vents at all high points and drains at all low points, including where offsets and bends in horizontal pipe runs create a low point. Provide drain points with bronze hose end drain valves.

G. Do not install piping above or through electrical rooms, telecommunication rooms, or similar room having a large collection of electrical equipment.

H. Keep pipe and fittings clean from cutting burrs, foreign matter and defects in structure and threading. Make all cuts square. Ream after cutting. Bevel plain ends of steel pipe. Clean off scale and dirt inside and outside before assembly. Remove welding slag or other foreign matter inside and outside.

I. Install piping within building concealed in walls, furred spaces, pipe spaces or above suspended ceilings. Do not build in or bury horizontal piping within partitions. Install exposed piping as closely as possible to walls, ceilings and columns, allowing space for installation of insulation and access for valve operation.

J. Install piping sections using greatest length possible in all cases. The use of short lengths socketed together will not be allowed.

K. The use of lampwick or other material for packing threads, caulking or wrapping of joints to stop or prevent leaks or correct faults is not permitted. The use of long screws having right and left hand threads or couplings is not permitted.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

M. Install piping to permit valve servicing and application of insulation.

N. Provide offsets and loops as required for piping crossing a building expansion joint to accommodate building movement, whether or not shown on the drawings.

O. Changes in Pipe Size and Direction

1. Make reduction or increase in pipe size with fittings. Use eccentric reducing fittings in horizontal piping. Use reducing tees in pressure piping for side outlet reduction only, not on run. Bushed fittings, notched or straight runs to form tees, or any similar fabrication method will not permitted.
2. Make changes in direction with standard fittings. Mitering of pipe to form elbows or similar fabrication method will not be allowed. Bending of piping will not be permitted.

P. Electrolysis Control

1. Install copper or brass piping or tubing in such a way as not to touch or come in contact with ferrous metals.
2. Where ferrous piping or equipment is connected to copper or brass piping, make connection with insulating or dielectric union to prevent electrolytic action between the ferrous and nonferrous metals. At branch connections off mains, provide shut off valve upstream of dielectric union in order to isolate downstream union.
3. Where copper or brass piping, tubing or fittings are anchored to, supported by, or come in contact with ferrous metal construction, provide an insulating nonconductor spacer of rubber, plastic or equivalent material to assure prevention of electrolysis.

Q. Equipment Piping

1. Verify final locations of equipment for rough in of piping connections.
2. Provide shut off valves in the supply and return to each item of equipment. Suitably locate equipment isolation valves to facilitate removal of equipment.
3. Provide piping from pump glands, cooling coil drain pans, relief valves or other drainage to spill over open sight drains, floor drains, or other trapped acceptable discharge, terminating with plain end cut at a 45 degree angle.

R. Expansion and Contraction of Piping

1. The piping installation shall be free of stress. Run all piping with full allowance for expansion or contraction. Base expansion calculations on 50 degree F installation temperature to 200 degree F for hot water systems and temperature of steam pressure for steam systems, plus 30% safety factor.
2. Evaluate the complete piping layout and notify Architect of additional anchors or expansion joints and any deviations required to compensate for expansion.
3. Make connections to equipment in such a manner as to eliminate undue strains in piping and equipment. Install sufficient number of elbow swings to allow for proper expansion and contraction of piping at the point of connection to mains and equipment.
4. Fabricate expansion loops with long radius welded fittings in steel piping and with long radius copper sweat fittings in copper piping.
5. Provide adequate pipe guides on each end of the expansion device to preserve alignment and pitch.
6. Install pipe hangers and supports in such a manner as to not cause an anchor condition in any direction.

S. Pipe Anchors

1. Install anchors where required to direct pipe expansion properly into expansion joints, loops or offsets and to prevent transfer of loading and stresses to connected equipment.
2. Pipe anchors may consist of heavy steel clamps bolted or welded to piping and provided with lugs and bolts for clamping and attaching anchor braces. Design anchors to restrict pipe movement and fasten to main members of building structure in most effective manner to secure desired results.
3. Do not attach supports, anchors or stays in places or in such a manner that will damage construction or integrity of the structure, either during installation, by weight of the pipe, or by expansion and contraction of the pipe.

T. Pipe Insulation Inserts and Shields

1. Refer to Section of Division 23, "HVAC Insulation" to coordinate specific insulation thicknesses and requirements. At hanger locations for insulated piping 1-1/2 inches (DN 40) and larger where hanger support is outside the insulation, provide inserts of exploded silica pipe insulation between pipe and hanger. Density and compression strength suitable for pipe size and support spacing as required by MSS SP-58, Paragraph 9 and MSS SP-69, Table 3. Provide inserts as required for smaller piping to prevent deformation of insulation. Inserts of equal thickness to adjoining insulation, provided with vapor retardant seals, and of proper length to fully support pipe at each hanger location. Manufactured by Value Engineered Products Max Span; or equivalent.
2. At all hanger locations for insulated piping where hanger is outside of insulation, provide galvanized sheet steel shield formed to fit insert/insulation, extending up to pipe centerline. Length 12 inch minimum when insert is not required. Where inserts are provided, length of shield 4 inches less than insert length. Provide shields 16 gauge for piping up to 4 inches (DN 100), 12 gauge for piping 6 inches (DN 150) and larger. Shields shall have preformed ridges on each side of hanger to prevent hanger from slipping along shield.
3. Preformed insulated pipe saddles may be used in lieu of insert and shield where appropriate. Thickness of insert or pipe saddle same thickness as pipe insulation.

3.6 WELDING, SOLDERING AND BRAZING

A. Do not employ workers who have not been fully qualified and certified for the specified procedures.

B. Pipe Welding, Black or Galvanized Steel Pipe: Perform all welding of black or galvanized steel pipe by shielded metallic arc method of fusion welding, in accordance with welding procedures of AWS (American Welding Society) D10.12 recommended procedures for welding low carbon steel pipe, or other approved procedure, conforming to requirements of ASME/ANSI B31.1 for high pressure steam boiler piping and B31.9 elsewhere.

C. Pipe Welding Stainless Steel Pipe: Refer to other Sections of Division 23 for welding requirements.

D. Structural Steel Field Welding: Comply with AWS D1.1 procedures for manual shielded metal-arc welding, appearance and quality of welds, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

E. Soldering: Comply with the requirements of the AWS Soldering Manual.

F. Brazing: Comply with the requirements of the AWS Brazing Manual and AWS A5.8 specification for filler materials for brazing.

3.7 UNIONS

A. In Screwed Steel Pipe, 2 inches (DN 50) and smaller: Screwed, Class 250 malleable iron, brass to iron seat, ground joint union with brass seat ring pressed into head piece. Provide galvanized unions in galvanized pipe.

B. In Welded Steel Pipe, 2 inches (DN 50) and smaller: Class 3000 carbon steel socket welded union, steel to steel seat and ground joint. Provide stainless steel in stainless steel piping.

C. In Copper tubing, 2 inches (DN 50) and smaller: Class 200 wrought copper, solder type, brass ground joint union.

D. In Brass Piping, 2 inches (DN 50) and smaller: Class 250 cast bronze, screwed ends, brass ground joint unions. Provide chromium plated unions in chromium plated piping.

E. Provide companion flanges in piping 2-1/2 inch (DN 65) and larger.

3.8 PIPING CONNECTIONS

A. Refer to other Sections of Division 23 for additional requirements.

B. Flanged Connections: Make with nonasbestos gaskets of 1/8 inch thick best quality material as recommended by manufacturer for the service application. For steam piping, factory manufactured for flange/connection size/type as manufactured by Flexitallic. For other piping services either Flexitallic or gaskets factory cut for flange size as manufactured by Garlock Packing Division, Colt Industries, or equal. Align flange surfaces parallel. Install gasket concentrically positioned. 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 using torque wrench.

C. Mechanical Couplings: Prepare pipe and install in accordance with manufacturer's instructions. Standard wall steel pipe either roll or cut grooved at Contractor's option, all sizes, except provide cut grooved as required to accommodate thermal expansion and contraction. Heavy wall steel pipe cut grooved all sizes. Light wall steel pipe roll grooved all sizes. Copper tubing roll grooved.

D. Soldered Joints: Unless noted otherwise, make with appropriate flux and solder. Clean tubing ends and fittings before assembly. For piping 2 inch (DN 50) and larger tin tubing and fittings before assembly. For tubing 2-1/2 inch (DN 65) and larger use circular flame torch for soldering. The use of lead flux or solder and finishing with 50-50 solder is prohibited.

E. Threaded Pipe: Make full, clean-cut standard ANSI/ASME B1.20.1 taper pipe threads using sharp dies. Carefully cut, ream or file out to size or bore, removing all chips. Use Schedule 80 pipe for all screwed close and shoulder nipples. Do not use all thread nipples. Provide teflon tape or other approved nontoxic joint compound, applied to male thread only.

F. Welding Connections: Use only factory made welding fittings, same weight as piping, on welded pipe, except that Bonney Forge WELDOLET or THREADOLET, or Allied Type 1 Branchlet fittings, of same weight as connecting piping, may be used for branch takeoffs two or more commercial pipe sizes smaller than main. All elbows long radius.

G. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

H. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

I. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

J. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657. Plain-End Pipe and Fittings: Use butt fusion. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.10 PROTECTION OF WORK

A. Clean pipe, tubing, fittings, valves, piping specialties, ductwork and equipment before installation and keep clean while the work is in progress.

B. Securely close open ends of pipe and tubing and openings in other material and equipment until installed, during installation, and until finally connected or otherwise finished, with caps, plugs or other approved closure devices designed for such service.

C. Protect factory finished equipment, fixtures and devices with approved temporary covering material where those items are installed so as to be subject to accidental damage or abuse. Contractor shall remove all temporary covering material at the conclusion of the work or as directed.

D. Protect the work of other trades and property of Owner from damage and assume full responsibility for the cost of repairing or replacing any damage to such work or property caused by the performance of the work under Division 23.

3.11 CLEANING OF SYSTEMS

A. Refer to Division 23 "HVAC Water Treatment" for additional cleaning and system flushing requirements.

B. Following completion of system testing, thoroughly clean all piping systems by flushing with water or other approved method, or as otherwise specified. Completely remove all dirt, scale, oil, grease and other foreign substances that may have accumulated in systems during installation.

C. Carefully wipe out, wire brush, or if necessary, sand blast sections of pipe lines between temporary or permanent strainers and equipment they are to protect. Replace all permanent strainer screens with temporary screens during cleaning process. Remove temporary screens and reinstall permanent screens after cleaning is completed.

D. Disconnect automatic devices that can become clogged during cleaning process and do not connect permanently until cleaning process is complete.

E. Clean all ductwork, piping and equipment of dirt, scale, plaster, concrete, splattered paint and other foreign matter.

F. Clean all grease and cuttings from stainless steel piping and trim.

G. Clean all strainers, dirt pockets, drip legs, traps and other accessories that may collect foreign matter.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.13 GROUTING

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

B. Packaging: Premixed and factory packaged. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

C. Clean surfaces that will come into contact with grout. Provide forms as required for placement of grout. Avoid air entrapment during placement of grout.

D. Place grout, completely filling equipment bases. Place grout on concrete bases and provide smooth bearing surface for equipment. Place grout around anchors. Cure placed grout according to manufacturer's written instructions.

3.14 HANGERS AND SUPPORTS

A. General

1. Support major piping 3 inch (DN 80) and above, ductwork, tanks and other equipment to the structure above (beams and girders) or by means of struts or brackets to columns. Do not support from floor or roof decks. Do not overload structural members to which supports are attached. Hanger spacing not to exceed MSS SP69.

a. Provide hangers, rollers, threaded rods, turnbuckles, deflection guides, deflection provisions, inserts, beam clamps and all miscellaneous specialties for attachment of hangers and supports to structure.

b. Provide all rods, angles, rails, struts, brace plates, structural steel, platforms and other items required for suspension or support of piping, ductwork, tanks and equipment.
c. Provide supplemental angles, channels, plates or other reinforcement where supports are required between building structural members. Size supports for weight of duct, pipe, pipe contents, equipment fittings and other items, plus a 200 pound (90 kg) live load. Attach supplemental supports in a manner that will not weaken or overload structural members. Weld steel according to AWS D-1.1.
d. Attach by welding, clamping, concrete inserts, drilled in mechanical type anchors (Hilti or equal) and other approved means. Adhesive type anchors are not approved.
e. Place grout under supports for equipment, and make a smooth bearing surface.
f. For seismic restraint, provide double-sided beam clamp loaded perpendicularly to beam for seismic anchor point.

2. No lead shield anchors, powder or power fasteners permitted for attachments.
3. Do not use perforated strap hangers. Do not use steel strap hangers on piping.
4. Wherever possible, support shall be provided directly to main steel or concrete framing beams. If spacing of structure exceeds spacing required to support the mechanical work, supplemental channel or unistrut framing shall be designed and provided by the Contractor.
5. Support all mechanical work independently of other trades. Under no circumstances shall work be supported or suspended from ceiling grids, piping or other supports by other trades.
6. Before drilling concrete for attachments, carefully check Drawings and Shop Drawings for such concrete and locate drilled holes to miss reinforcing by at least 1 inch.
7. Inserts in precast concrete to support Work of Division 23 will be furnished and installed by precast concrete supplier. Prepare drawings locating such inserts for review by Architect before distribution.

8. Supports from Joist Construction: Support suspended piping, ductwork and equipment at joist panel point locations. Provide any supplementary steel angles or channels as required to fasten to panel point locations. Where this is not possible, reinforce joist from point of support to joist panel points on each side of support with steel angles welded to top and bottom joist chords. Do not hang from joist bridging. Maximum point load and maximum additional load per existing joist shall not exceed the loads in the table below:

Existing Joist Size	Maximum Point Load	Maximum Additional Load per Existing Joist
SJ8	75# (35 kg)	300# (135 kg)
SJ10	75# (35 kg)	300# (135 kg)
SJ12	75# (35 kg)	300# (135 kg)
SJ14	150 # (70 kg)	1000# (450 kg)
SJ16	100# (45 kg)	500# (225 kg)

B. Inserts

1. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.
2. Set inserts in position in form work in advance of concrete work. Provide reinforcement rod placed through opening on top and bent over adjacent concrete reinforcement rods.
3. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
4. Where inserts are omitted, if approved by Architect, drill through concrete slab from below and provide rod with recessed square steel plate and nut above slab or provide drilled in mechanical type anchors, Hilti or equal, after concrete is completely cured.

C. Pipe Hangers and Supports

1. Unless otherwise required to avoid overloading of structural members or for seismic restraint, support horizontal steel and copper piping as follows:

Nominal Pipe Size (inch) (DN)	(a)Maximum Distance Between Support (feet) (m)		Hanger Rod Diameter (inch) (mm)
	Steel Pipe	Copper Tubing	
up to 3/4 (DN 20)	6 (1.8)	5 (1.5)	3/8 (9.5)
1 to 2 (DN 25 to 50)	6 (1.8)	6 (1.8)	3/8 (9.5)
2-1/2 to 3-1/2 (DN 65 to 90)	10 (3.0)	8 (2.4)	1/2 (12.5)
4 & 5 (DN 100 to 125)	12 (3.5)	10 (3.0)	5/8 (15.9)
6 to 8 (DN 150 to 200)	12 (3.5)	10 (3.0)	3/4 (19)
10 to 12 (DN 250 to 300)	12 (3.5)	10 (3.0)	7/8 (22.25)
14 (DN 350) and over	12 (3.5)	-	1 (25)
Trapeze Hanger Rod			(b)

a. Provide additional supports as required to avoid overloading of supporting structure. Reduce distance where so required by applicable codes.
b. As required to carry weight of trapeze channel, span of piping with contents, insulation and supports, plus a 200 pound (90 kg) live load.

2. Install hangers to provide minimum 1/2 inch (12.5 mm) clear space between finished covering and adjacent work.
3. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers and expansion joints/loops.
4. Place a hanger within one foot of each horizontal elbow.
5. Use hangers that are vertically adjustable 1-1/2 inch (35 mm) minimum after piping is erected.
6. Vertical Piping Support:

a. Unless otherwise required to avoid overloading, of structural members or for seismic restraint, support vertical piping with clamps spaced appropriately as to type and weight of piping, minimum spacing at every other floor and below roof. Support vertical soil pipe at each floor at hub. For exposed piping in stairs and finished areas, locate clamps below floor and secure to structure below floor as required.
b. Support vertical steel pipe at a maximum of 15 feet spacing.
c. Support vertical copper pipe and tubing at a maximum of 10 feet spacing.

7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers. Space hangers for smallest pipe size or provide intermediate supports for smaller pipe as specified above for individual pipes.
8. Where practical, support riser piping independently of connected horizontal piping.
9. Support pipe runs in a manner to minimize stress in the pipe or tubing and on bodies of valves and fittings.
10. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units, and so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
11. Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31.9 "Building Services Piping" is not exceeded.
12. For piping subject to sweating (e.g.: domestic cold water, chilled water, refrigerant suction, drain piping for air conditioning equipment, heat recovery piping, etc.) and for insulated piping requiring roller supports, install hangers outside insulation and provide pipe insulation protection shields as specified in this section. For all other piping, hanger may be attached to the piping before insulation is applied or may be installed outside the insulation with insulation protection shields.
13. Do not support nonferrous piping with ferrous materials even on a temporary basis.
14. Do not support piping or ductwork from other piping or ductwork.
15. Install hanger rods subjected to tension only. Accomplish lateral and axial movements by proper linkage in rod assembly. Secure hanger to hanger rod with two bottom lock nuts.

D. Duct Hanger and Supports: Refer to Section 23 30 00 "Ductwork and Ductwork Accessories".

3.15 IDENTIFICATION

A. Identify all new and altered equipment, new and altered exposed and concealed ducts and new and altered exposed and concealed pipe with legible lettering, applied after finish painting, in a color to contrast with basic color in accordance with ANSI A13.1 and OSHA.

B. Identify piping by name of pipe content and direction of flow near major equipment items, adjacent to valves or flanges, adjacent to gauges or thermometers, at each tee, at changes in direction, on each side of a penetration of a wall or floor, at each access door or panel and then at maximum 20 foot (6 m) centers in congested areas and 50 foot (15 m) intervals elsewhere; indicate flow direction with arrows. Identification shall be by means of plastic markers or tape or painted on the finished pipe surface by using stencils. Lettering shall not be smaller than one third of the pipe diameter and directional arrows not less than 1/2 inch wide and 12 inches long.

C. Identify equipment and operating devices such as switches, starters and similar equipment, by the equipment numbers shown on Drawings or by the Owner's numbering system, if so directed.

1. Include the type of service or the name of areas served.
2. Lettering minimum 1 inch high.
3. Nameplates shall be two tone plastic, or printed white paper enclosed in a transparent, laminated plastic case with permanently sealed edges.
4. Attach securely to equipment, or where this is not practicable attach by brass link chains.
5. Do not stencil surfaces exposed in public areas.

D. Furnish for each valve, except those immediately adjacent to apparatus, a 2 inch diameter nonferrous metal tag with figures stamped on the tag.

1. Number tags for HVAC H-1, H-2, etc.; Use Owner's numbering system if so directed.
2. Fasten tags to valves with nonferrous S hooks and nonferrous chains.
3. Where valves are located above removable acoustical tile ceilings, identify the tile section below the valves by an approved color pin system.
4. Furnish duplicate framed schedules showing the location of each valve, system or equipment it serves, manufacturer, and figure number.

E. Identify exposed ductwork similar to piping.

F. Identify access doors to fire dampers with access panel markers or by stencils with the words "Fire Damper Access" except for dynamic fire dampers, use the words "CAUTION Dynamic Fire Damper Access". Provide approved markers to locate fire dampers concealed above ceilings.

3.16 TESTING OF PIPING SYSTEMS – COMMON REQUIREMENTS

A. Refer to individual piping system specifications elsewhere in Division 23 for additional piping system testing requirements.

B. Provide materials and equipment required for testing. Test and make tight all new piping systems **and alterations and connections to existing piping system.**

C. Take precautions during testing to insure safety of personnel and equipment. Provide systems to be pressurized with appropriate gauges and blowouts or relief valve set at a pressure no more than one third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test. Make good at no increase in Contract sum damage to work or work of other trades caused by failure to observe proper precautions.

D. Test piping systems prior to application of insulation. Testing as stipulated herein shall be considered minimum, and where tests stipulated by lawful jurisdictional authorities exceed these requirements, such more stringent tests shall be performed. Tests shall be witnessed and approved by the authorities having jurisdiction over the work.

E. Concealed work shall remain uncovered until required tests have been completed. Provide proper sectionalizing devices so that portions of a system may be tested as appropriate.

F. Isolate and exclude from tests all in line equipment, instruments, gauge glasses, flow meters and all other devices not capable of withstanding test pressure.

G. Use ambient temperature water as testing medium, except where otherwise specified and except where there is a risk of damage due to freezing.

H. Apply soap solution to all joints of pneumatically tested systems while system is being subjected to test pressure.

I. Maintain test pressures sufficient length of time to permit thorough inspection of all joints. Where leaks are observed, replace defective work or material. Caulking of screw joints or holes is not acceptable. Repeat entire test as many times as necessary, until successful completion of test with no leaks.

J. Prepare written report of testing.

3.17 BALANCING, ADJUSTING AND PERFORMANCE TESTING

A. Testing, adjusting and balancing of air and water systems will be provided under Division 01 "Testing, Adjusting and Balancing of HVAC Systems".

B. Installing Contractor(s) responsible for the work specified in Division 23 shall perform all work necessary to place systems in full operation prior to start of testing, adjusting and balancing work. In addition, Installing Contractor shall perform certain additional preparatory work required for testing, adjusting and balancing as specified in various Sections of Division 23.

C. Provide notice upon completion of all preparatory work and all initial operational testing required as part the Work. Perform additional operational testing on equipment, or systems, as directed and to extent and for duration deemed necessary, to demonstrate that systems are performing properly and delivering quantities in accordance with the requirements of the Contract Documents.

D. Cooperate with testing, adjusting and balancing Contractor in coordination and scheduling of testing, balancing and adjusting work. Furnish approved manufacturer's technical data and shop drawings for equipment, including fan and pump performance curves.

3.18 INSTRUCTION AND DEMONSTRATION

A. Upon completion of all work and all tests, and at a time mutually agreed on by Contractor, Architect and Owner, Installing Contractor shall operate systems in all parts and at their expense for sufficient length of time to demonstrate the mode of operation and definitively determine whether the systems as a whole are in first class working condition. Immediately correct, at no cost to Owner, any defects that may develop during this period of operation and place systems in first class working condition before being finally turned over to Owner.

B. Provide experienced operating personnel to instruct Owner's authorized employees in the operation, adjustment and maintenance of systems and equipment installed under this Contract. Provide instructions for the period of time appropriate for the size and complexity of the system, or as requested by Owner.

3.19 MANUFACTURER'S SUPERVISIONS AND STARTUP SERVICE

A. Include manufacturer's supervision/startup/certification and special instruction service for equipment as specified in various Sections of Division 23. Be responsible for properly making arrangements for and coordinating with the manufacturer to provide the specified work. Make any corrections/modifications to the installation as required by the manufacturer at no additional cost to Owner.

B. The manufacturer's engineer or authorized service personnel shall check the equipment for its conformance to the Specifications, for proper installation and run the system in all modes of operation to ascertain that the unit will function properly. Make necessary adjustments to insure optimum efficiency and trouble free service.

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SECTION 23 05 13 - ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes extent of electrical equipment and electrical wiring that is responsibility of Division 23.

B. Section includes general requirements for motors installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Related Sections:

1. Variable Frequency Motor Speed Controllers furnished by Division 23 are specified in Division 26.

1.3 REFERENCE STANDARDS

A. ANSI/IEEE 112 (C50.20): Test Procedure for Single Phase Induction Motors.

B. ANSI/IEEE 114 (C50.21): Test Procedure for Polyphase Induction Motors and Generators.

C. NFPA 70: National Electric Code (NEC)

D. UL: Underwriters Laboratories

1.4 SUBMITTALS

A. Product Data: Include with equipment submittals, data pertinent to electrical characteristics; motor size, type, power requirements, wiring requirements.

1.5 QUALITY ASSURANCE

A. Provide electrical products, including those factory mounted or factory furnished, which have been tested, listed and labeled with Underwriters' Laboratory (UL) or Electrical Testing Laboratory (ETL).

B. There shall be no field modifications made to any materials, equipment and systems that would violate the listing and labeling.

C. Comply with Division 26, NEC and NEMA as applicable to wiring methods, materials and equipment and equipment, construction and installation.

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

B. Smoke Dampers: Smoke dampers will be provided by Division 23. Smoke damper will be wired to the Fire Alarm system by Division 28. Wiring and addressable interface module will be provided by Division 28. Division 25 will provide contactor and relay and wiring to BAS system.

C. Air Volume Control Boxes: Air volume control boxes with integral 120/24 volt transformer will be provided by Division 23. Power wiring to air volume control boxes will be provided by Division 26. Control wiring to and from air volume control boxes will be provided by Division 25.

D. Wiring Under Division 26 "Electrical"

1. Power wiring under Division 26 will include power feeders from source of building power to wiring terminals on the equipment, unit mounted disconnects, or control panels.
2. Where disconnect switches for equipment are provided by Division 26, power wiring under Division 26 will include wiring from disconnect to wiring terminals on the equipment.

E. Wiring Under Division 25 "Instrumentation and Control For HVAC"

1. Wiring under Division 25 shall include all connections to control devices, wiring of pressure and flow control switches, flow meters and similar mechanical-electrical devices for mechanical systems to control panels, interlock wiring, control relays, and minor power wiring to auxiliary components for major pieces of apparatus such as damper motors, solenoid valves and control valve motors.

F. Provide all other power and control wiring for Division 23 systems and equipment in accordance with the requirements of Division 26, required for complete operation, including wiring that is specified for factory prewired equipment, but not so provided.

PART 2 - PRODUCTS

2.1 ELECTRICAL WIRING

A. Electrical wiring provided by Division 23 shall be in accordance with the requirements of Division 26.

2.2 MOTORS

A. Acceptable Manufacturers:

1. Toshiba
2. General Electric
3. Lincoln
4. Reliance
5. U.S. Electric
6. Marathon
7. Baldor

B. General Motor Requirements

1. Construct in accordance with the latest NEMA MG 1 standards and UL 1004, test in accordance with NEMA MG 1, ANSI/IEEE 112 and ANSI/IEEE 114. Except where more stringent requirements are indicated, comply with the following.
2. Single phase/3 phase (polyphase) and voltage characteristics as scheduled on drawings, 60 Hz.
3. Service factors indicated for motors are minimum values and apply at frequency and utilization voltage at which motor is connected. Provide motors that will not operate in service factor range when supply voltage is within 10 percent of motor voltage rating.
4. Class B insulation unless otherwise specified.
5. Provide each motor with a conduit terminal box or factory installed cord set with molded plug as applicable.
6. Provide motors with grease or lubrication fittings. For specific applications, and at the approval of the Architect, the use of permanently lubricated or lifetime bearings will be permitted.
7. Open dripproof (ODP) or totally enclosed fan cooled (TEFC) type with a minimum service factor of 1.15 unless otherwise specified herein or in other section of the specifications.

C. Motor Characteristics

1. Duty: Continuous duty at 100 percent of rated capacity at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

D. Polyphase Motors

1. Squirrel cage induction type conforming to the following requirements unless noted otherwise:
2. Description: NEMA MG 1, Design B, medium induction motor, unless otherwise required by starting torque.
3. Separate winding for each speed for multispeed motors.
4. Efficiency:

    a. Single speed motors 75 Hp and smaller shall be of "Premium efficiency" design, as defined in NEMA MG-1. Class F insulation.
    b. Motors driven by variable frequency motor speed controller (VFD) shall be "Premium" efficiency, as defined in NEMA MG-1. NEMA Design B, Class H insulation.

5. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. For motors 1.0 Hp and smaller, prelubricated, antifriction sleeve bearings.
6. Motors drawing 1000 watts or more at full load shall have a power factor rating of at least 85% without external capacitor correction. Verify efficiency in accordance with NEMA MG-1. Test per NEMA MG-1, ANSI/IEEE 112. Display efficiency on nameplate in accordance with NEMA MG-1.
7. Motors used with reduced-voltage and multispeed controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
8. Special Requirements:

    a. Motors installed in air handling unit directly downstream of cooling coils or humidifiers shall be totally enclosed fan cooled (TEFC) type.
    b. Motors driven by variable frequency motor speed controller (VFD) shall be inverter duty rated, thermally protected, in full compliance with NEMA MG-1 Part 31.
    c. For motors driven by VFD, provide motor shaft grounding ring (SGR) to protect against electrical discharge machining (EDM) motor bearing damage.
    d. Provide next size larger motor and drive, where fan motor brake horsepower, including all drive and belt losses, exceeds the following limits:

        1) 85% of nameplate horsepower for motor 40 Hp and smaller in size.
        2) 90% of nameplate horsepower for motor 50 Hp through 100 Hp in size.
        3) 95% of nameplate horsepower for motor larger than 100 Hp.

E. Single Phase Motors

1. Motors larger than 1/20 hp shall be energy efficient capacitor start type to suit starting torque and requirements of specific motor application:
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.3 VARIABLE FREQUENCY MOTOR SPEED CONTROLLERS (VFD)

A. Variable frequency motor speed controllers (VFD), including line reactor and/or harmonic filter as required, shall be furnished by Division 23 in accordance with Division 26 Section "Variable Frequency Motor Speed Controller (VFD)".

B. It shall be the responsibility of Division 23 Sections to properly match the motor and drive.

C. All variable frequency motor speed controllers furnished by Division 23 shall be of the same manufacturer.

2.4 MOTOR STARTERS

A. Motor starters for chillers and certain packaged equipment will be furnished by equipment manufacturer(s) as specified in their respective sections of Division 23. All other motor starters, except variable frequency drives, shall be provided by Division 26.

2.5 POWER FACTOR CORRECTION

A. Power factor correction for certain packaged equipment will be furnished by equipment manufacturer(s) as specified in their respective sections of Division 23.

B. For each motor 25 hp and larger, except those driven by a VFD, furnish 3 phase, 60 hertz, biodegradable, low toxicity type capacitor for power factor correction with maximum rating allowed by motor manufacturer sufficient to raise overall motor power factor to 95%.

C. Provide NEMA enclosure with gray enamel finish, porcelain bushings, non-PCB impregnated dielectric resistors, current limiting fuses, mounting brackets, internal connections and appurtenances, including blown fuse external indicator.

D. Factory test capacitors for compliance with referenced NEMA and ANSI/IEEE Specifications. Submit certified test reports with equipment shop drawings.

2.6 CONTROL PANELS

A. Include in control panels provided as a part of apparatus specified in Division 23, fused disconnect, circuit breaker or motor circuit protector combination starter with overload protection for each motor, contactors, and electric heaters, if required. Provide 120 volt control circuit and other required circuit protection. Where remote controls are required, they shall operate at 120 volt maximum, with properly fused control transformer provided for that purpose.

PART 3 - EXECUTION

3.1 ELECTRICAL WIRING

A. Power wiring will be provided under Division 26 and control wiring will be provided under Division 25. Provide power and control wiring for Division 23 systems and equipment for interconnecting wiring on apparatus that has not been factory installed.

3.2 MOTORS

A. Provide electric motors required for equipment specified in the various sections of Division 23, designed and wound for electrical characteristics shown on the Drawings.

B. Select motors for quiet operation and for sufficient capacity to operate driven devices under all conditions of operation without overloading.

C. Install motors in accordance with manufacturer's published instructions. Mount direct drive connected motors securely in accurate alignment. For belt drive motors, use adjustable mounting bases, align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.

D. Extend lubrication lines to accessible locations.

E. Startup

1. Check operating motors, both factory and field installed, for unusual conditions during normal operation. Coordinate with the balancing and commissioning of the equipment for which the motor is a part.
2. Report unusual conditions and correct deficiencies.

3.3 VARIABLE FREQUENCY MOTOR SPEED CONTROLLERS (VFD)

A. Deliver variable frequency motor speed controllers not factory mounted on equipment to Division 26 for field installation and wiring.

3.4 MOTOR STARTERS

A. Deliver motor starting equipment not factory mounted on equipment to Division 26 for field installation and wiring.

3.5 POWER FACTOR CORRECTION

A. Deliver capacitors not factory mounted on equipment to Division 26 for field installation and wiring.

END OF SECTION 23 05 13

SECTION 23 05 48 - VIBRATION ISOLATION AND SEISMIC RESTRAINTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Vibration isolation devices, accessories, materials and related items for new and altered equipment, piping and ductwork as may be required to prevent the transmission of vibration to the building structure.

2. Seismic restraint devices, accessories, materials and related items for new and altered equipment, piping and ductwork as may be required to keep all components in place during a seismic event and operational where this specification so requires.

3. Requirements for Certification of seismic analysis, design and installation.

B. Refer to Structural Drawings and Division 01 "Summary of Work" for seismic criteria and site specific seismic restraint design parameters to be used for this project.

1.3 REFERENCES

A. ASCE: American Society of Civil Engineers, ASCE 7, latest edition.

B. ASHRAE: American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Applications Handbook, latest edition.

C. ASTM: American Society for Testing and Materials.

D. AWS: American Welding Society.

E. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association, Duct Construction Standards – Metal and Flexible, latest version.

F. SMACNA: Seismic Restraint Manual Guidelines for Mechanical Systems, latest version.

G. MSS: Manufacturer's Standardization Society.

H. CBC: California Building Code, latest edition.

I. OSHPD: Office of Statewide Health Planning and Development.

1.4 DEFINITIONS

A. Failure: For the purpose of this project, is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 inch and/or horizontal permanent deformation greater than 1/4 inch.

B. Isolation Manufacturer: For the purpose of this project, manufacturer of vibration isolation and seismic restraint equipment.

C. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

D. Positive Attachment: A cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps and power shots for support rods of piping, ductwork, or any other equipment are not acceptable on this project as positive attachment.

E. Restraint: Device(s) intended to keep component in place during a seismic event.

F. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

G. High Hazard Systems

1. Systems conveying material that is either toxic or potentially explosive and in significant quantity could pose a threat to the general public.
2. Fuel oil, natural gas, propane, compressed air, high pressure steam or any piping containing flammable, combustible, toxic or corrosive material.

H. Life Safety Systems:

1. Supply, fresh air, exhaust, and relief air systems on automated emergency smoke control sequence, or manually controlled smoke evacuation and purge systems.
2. Hospital heating and air-conditioning systems required to maintain normal ambient temperature.
3. Mechanical systems that support the operation of or are connected to emergency power generation equipment.

I. Refer to ASCE 7 for additional definitions of items related to seismic restraints.

1.5 SUBMITTALS

A. Product Data: Annotate to indicate application of each product submitted and compliance with the specifications.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style material, strength, fastening provision, and finish for each type and size of seismic restraint component used.
3. Installation instructions and requirements, including all anchoring and fastener torque requirements.

B. Product Schedule or List: Provide schedule of all vibration isolated and restrained equipment and all restrained but not vibration isolated equipment, all vibration isolated and restrained piping and ductwork systems and all restrained, but not vibration isolated piping and ductwork systems. Submit separate schedules for "Vibration Isolated and Restrained" and for "Restrained but Not Vibration Isolated". Include the following for each piece of equipment and, as applicable, for each piping and ductwork system:

1. Identification. Include equipment ID where applicable
2. Isolator type(s) with identification reference numbers of applicable product data and shop drawings.
3. Actual load for each isolator type.
4. Actual static deflection expected under actual load for each isolator type.
5. Specified minimum static deflection under actual load for each isolator type.
6. Seismic restraint(s) with identification number(s) of applicable product data and shop drawings. Include overstressed condition information, if any, as required by the Article titled "Seismic Restraint Design Engineer's Responsibilities" in Part 1 of this section. Do not include calculations with submittal. Calculations will not be reviewed.

    a. Initial and final deflection, anticipated movement and final floor loading for spring riser system.

C. Shop Drawings:

1. Fabrication details of steel rails, steel base frames and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method and location of equipment bolts.
2. Drawings showing methods of suspension, support guides for piping and ductwork.
3. Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.
4. Drawings showing number and location of seismic restraints and anchors for each piece of equipment and each piping and ductwork system.
5. Specific details of restraints including anchor bolts for mounting at each location, for each piece of equipment and for pipe, conduit and duct locations.
6. Methods and details for vertical restraints.
7. Details and sizing of housekeeping pad(s) showing reinforcement, method of attachment to structure and method of attachment of equipment restraint(s).
8. All other special details necessary to convey complete understanding of work to be performed.
9. Provide the number, size and location of braces and anchors for suspended piping and ductwork on shop drawings.

D. Certification of Seismic Analysis and Design: Statement on seismic design engineer's letterhead stationary with original signature of an authorized representative of the manufacturer certifying that, as required by the Article "Seismic Restraint Design Engineer Responsibilities" in Part 1 of this section:

1. Seismic restraint design calculations have been completed and stamped by a registered engineer in the same state as the project, including name, license number and state of registration of responsible engineer. Do not include calculations with submittal.
2. All overstressed conditions have been included in the submittal.

3. Seismic restraints and attachments are capable of safely accepting loads resulting from the site specific seismic forces when installed in accordance with manufacturer's instructions.

E. Certification of Component Manufacturer Seismic Compliance:

1. For life safety and high hazard components and systems, provide component manufacturer's Approved Agency Certificate of Compliance for their equipment when used on project with Seismic Design Category C through F, including testing certification.
2. All other components, equipment manufacturer must provide certification product has been tested or analyzed to withstand the site specific restraining loads. Seismic restraint design engineer shall review products for capability to withstand project design anchoring loads.
3. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the site specific seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the site specific seismic forces specified and the unit will remain fully operational after the seismic event."

4. Dimensioned Outline Drawings of Unit Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.
5. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

F. Certificates: All seismic components to be used in association with OSHPD projects must be submitted with OSHPD pre-approval certification stamp.

1.6 QUALITY ASSURANCE

A. It is the objective of this specification to provide the design and installation requirements for vibration isolation equipment and devices for the avoidance of excessive noise and vibration in the building(s) due to the operation of machinery or equipment and/or due to interconnected piping, ductwork or conduit, and to provide the design and installation of restraint equipment and devices for seismic restraint for the mechanical systems

B. All vibration isolation equipment and devices, including auxiliary steel bases and pouring forms, and all seismic restraint equipment and devices shall be the products of a single manufacturer, hereinafter called the isolation manufacturer, unless otherwise allowed in writing by the Architect, shall be certified by the isolation manufacturer and shall be furnished by the isolation manufacturer or his authorized representative, who shall be responsible for performing all work specified in this section to be performed by the isolation manufacturer or his representative and for coordination of all phases of the work.

C. This specification represents the minimum requirements for seismic consideration. All systems must be installed in strict accordance with seismic restraining forces and in compliance with site specific design parameters. Applicable codes and component manufacturer's standards and written

instructions shall be complied with. Whenever a conflict occurs between codes, manufacturer's standards and requirements in this Section, the most stringent shall apply.

D. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel.

E. Quality Assurance Program: The quality assurance plan shall be included when required by the applicable building codes. The design of each seismic restraining system shall include a written quality assurance plan prepared by a professional engineer registered in the same state as the project. The quality assurance plan shall identify the following:

1. Seismic restraining systems that are subject to quality assurance:

   a. Constant Volume Boxes
   b. Booster Fans
   c. Reheat and Steam Dispersion Coils

2. Special inspections and testing to be provided as per applicable code requirements.
3. The type and frequency of testing and special inspections.
4. The frequency and distribution of testing and special inspection reports.
5. The structural observations to be performed.
6. The required frequency and distribution of structural observation reports.

F. Contractor must select a single seismic restraint system pre-designed to meet the requirements of the applicable building code.

1.7 DESIGN REQUIREMENTS

A. Refer to Section 23 05 00 Article titled "Seismic Requirements."

B. Design seismic restraints to safely anchor and resist earthquake generated external horizontal forces of not less than those values required by the applicable California Building Code in any direction at the center of mass without failure or permanent displacement.

C. Non-simultaneous vertical force shall be 66% of the horizontal force.

D. Internally isolated and restrained equipment may be used in lieu of specified external isolation and restraint provided all site specific seismic design parameters are met.

E. Exclusions for seismic restraint of ductwork and piping shall be according to referenced code.

F. Expected noise levels in various parts of the building shall conform to room criteria (RC) recommendations as set forth in the latest edition of the ASHRAE HVAC Applications Handbook. The midpoint range of the NC criteria curves shall apply.

G. Isolation manufacturer shall have the responsibility to determine the base type, if any, and the amount of spring deflection required for each isolator to achieve optimum performance, prevent the transmission of objectionable vibration and meet the noise criteria referenced herein. Select isolation in accordance with the requirements of the latest edition of the ASHRAE HVAC Applications Handbook. The following shall apply:

1. 30 to 40 Foot (9 to 12 Meter) Floor Span: Use for locations above grade which are adjacent to sensitive occupied spaces or on lightweight or flexible construction. The span is included for reference only and shall not be the primary consideration in design.
2. 20 to 30 Foot (6 to 9 Meter) Floor Spans: Use for locations above grade as appropriate for construction.
3. Up to 20 Foot (6 Meter) Floor Span: Use for equipment on ground supported slabs adjacent to or below noise-sensitive areas.
4. Grade Supported Slab: Use for equipment on ground supported slabs which are remote or are not adjacent to or below noise- sensitive areas.

1.8 COMPONENT MANUFACTURER'S RESPONSIBILITIES

A. Seismic restraint and vibration isolation component manufacturer shall have the following responsibilities:

1. Select vibration isolators, which will enable the noise criteria standards to be met, to the extent that the vibration isolators can control the noise. Determine vibration isolation and seismic restraint sizes and locations.
2. Furnish vibration isolation systems and seismic restraints as scheduled or specified.
3. Guarantee specified isolation system deflection.
4. Provide design and application of seismic restraints in accordance with the more stringent of the requirements of the referenced building code, SMACNA standards and the requirements of latest version ASHRAE Applications Handbook.
5. Provide installation instructions, drawings and field supervision to assure code compliant installation and performance. The installation of all vibration isolation units and seismic restraints, and associated hangers and bases, shall be under the direct supervision of the manufacturer's component application Engineer or their chosen representative. Upon completion of installation and after system is put into operation, representative shall make a final inspection and submit report to Architect in writing certifying that the installation is in compliance with site specific code and specification requirements. The completed Certification shall be submitted within 30 days of project completion.
6. Provide component certification of seismic restraints and attachments anchored to building structure resulting from seismic restraint forces determined by engineering calculations using site specific design parameters. Certification must be verified by a licensed engineer.
7. Design restraining devices to comply with thermally active components in such a manner that does not impose load due to thermally generated movement to building structure.
8. Advise Contractor of special size and anchor bolt requirements for foundations and housekeeping pads to develop strength equal to that for which the seismic restraints are designed to anchor and certify same.

1.9 SEISMIC RESTRAINT DESIGN ENGINEER'S RESPONSIBILITIES

A. Seismic Restraint Design Engineer retained by the Mechanical Contractor as required shall have the following responsibilities:

1. Seismic restraint application calculations, seismic restraint analysis and design certification.
2. Provide a written seismic restraint quality assurance document.

3. Registered Professional Engineer in the state where the project is located.
4. Identification of any overstressed conditions and notification to Architect of overstressed conditions.
5. Review of seismic restraint manufacturer's component certifications.
6. Provide special inspections for this project as required by applicable codes and standards.
7. Shop drawing review, design and certification of compliance with site specific seismic restraint design.
8. Provide calculations to determine restraint loads resulting from site specific seismic forces and in governing codes and project seismic restraint requirements; with a minimum seismic acceleration applied at the equipment center of mass as specified in the "Design Requirements" Article in Part 1 of this section. Seismic calculations shall be certified by a licensed engineer, experienced in the design of seismic restraints. Submit calculations with professional engineer's stamp and signature to Owner for record purposes. Calculations included in submittal will not be reviewed.
9. Check the structural members of the building for localized stress at points of attachment for seismic restraint. The Engineer shall provide to the Architect the magnitude of seismic restraint force and include direction on shop drawings, together with computation of stress conditions at localized attachments only in the event that an overstressed condition is determined by the Engineer. The Engineer shall certify that the Architect has been advised of all overstressed condition information. The Architect will review only such identified locations for additional bracing or reinforcing at these localized conditions.

1.10 COORDINATION

A. Coordinate work with other trades to avoid having isolated systems coming in contact with the building. Inform other trades following this work to avoid causing any contact which would reduce the vibration isolation.

B. Coordinate size, location and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pad.

C. Bring to the Architect's attention in writing prior to installation any conflicts with other trades which will result in unavoidable contact to the equipment, piping, etc., described herein, due to inadequate space, etc. Corrective work necessitated by conflicts after installation shall be at the Contractor's expense.

D. Bring to the Architect's attention in writing any discrepancies between the specifications and field conditions, changes required due to specific equipment selection, etc., prior to installation. Corrective work necessitated by discrepancies after installation shall be at the Contractor's expense.

1.11 INSPECTION AND INSTRUCTION

A. Notify the isolation manufacturer's representative prior to the general installation of vibration isolation devices and seismic restraints so that the isolation manufacturer's representative can instruct and demonstrate the proper installation procedures with the Contractor's foremen.

B. Comply with written instructions from the isolation manufacturer's representative as to the proper installation and adjustment of vibration isolation devices and seismic restraints.

C. Obtain inspection and approval from the isolation manufacturer's representative of the completed installation. Perform all work and make all adjustments as stated in the quality assurance document as provided by the isolation manufacturer.

D. Obtain inspection and approval from the isolation manufacturer's representative, and perform all directed work and adjustments, of any installation to be covered or enclosed prior to such closure.

E. Where special inspection and periodic special inspection of seismic restraints is required by the referenced building code, Contractor must submit a written statement of responsibility as part of the Quality Assurance Program including, identification of components, control procedures for all inspection and testing including frequency and method of reporting, and list of qualified personnel responsible for certifying seismic restraints.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Acceptable Manufacturers :

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Mason Industries
4. M.W. Sausse (Vibrex)

B. General:

1. Clean and paint steel components, and zinc-electroplate all nuts, bolts and washers. Clean structural steel bases of welding slag and prime with zinc-chromate or metal etching primer.
2. All springs installed out-of-doors shall be cadmium plated, zinc electroplated or powder-coated, hardware and other metal parts installed out-of-doors shall be galvanized, zinc electroplated or cadmium plated. Non Electro-Plated zinc coating shall be by hot dipped galvanizing and shall comply with ASTM-B 17 salt spray test standards and Federal Test Standard No. 14.
3. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
4. Isolator types are scheduled to establish minimum standards. At Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.
5. All static deflections stated are not "minimal" or "rated" deflections, but are the minimum acceptable deflection for the mounts under actual load as certified by the manufacturer. Isolators selected solely on the basis of rated deflections are not acceptable and will be rejected.
6. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of compressed height of spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of rated deflection. Springs

shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1/1. All mounts shall have leveling bolts.

7. All elastomeric isolation elements shall be fabricated of neoprene or high quality synthetic rubber with anti-ozone and antioxidant additives, and shall be cured to eliminate curing outgasing. The formulation shall have a shore hardness of 30 to 60 $\pm$5, after minimum aging of 20 days or corresponding oven-aging. Elements used in restraints shall be bridge-bearing quality.

C. Spring Isolators, Type FSN (Floor-Spring-Neoprene): Freestanding, laterally stable, combination coil-spring and elastomeric isolator with spring and insert in compression (ASHRAE Type 3).

1. General: Vibration isolation hangers consist of a freestanding, laterally stable steel spring and a neoprene element in series, contained within a steel housing. Make spring diameters and hanger housing lower hole sized large enough to permit hanger rod to swing through a 30° arc before contacting housing or make equivalent alternative provisions to allow specified movement.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene with a 0.3 inch minimum static deflection. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

D. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

E. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

F. Resilient Penetration Sleeve/Seal: Field fabricate from pipe or sheet metal section 1/2 inch to 3/4 inch larger in each dimension than penetrating element in all directions around the element. Use to provide a sleeve through construction penetrated. Extend sleeve 1 inch beyond penetrated construction on each side. Pack annular space between sleeve and the penetrating element tightly with glass fiber or mineral wool to within 1/4 inch of ends of sleeve. Fill remaining 1/4 inch space on each side with acoustical sealant to form an airtight seal. Penetrating element shall be able to pass through sleeve without contacting sleeve. Alternatively, prefabricated sleeves accomplishing same result are acceptable.

G. Grommets: Apply a formed grommet to prevent bolts from directly contacting the isolator base plate and sized so that they will be loaded within the manufacturer's recommended load range.

2.2 SEISMIC RESTRAINT DEVICES

A. Acceptable Manufacturers:

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control
3. Mason Industries
4. TOLCO Incorporated; a brand of NIBCO INC.
5. Mason Industries
6. M.W. Sausse (Vibrex)

B. General Requirements for Restraint Components:

1. Restraints shall be capable of safely accepting external forces specified in the DESIGN REQUIREMENTS article in Part I of this section, without failure, shall maintain mechanical systems, and accessories in a captive position, and shall not short circuit vibration isolation systems or transmit objectionable vibration or noise.
2. EXCEPT FOR TYPE I RESTRAINT, systems that incorporate vibration isolation support within seismic restraint housing are not permitted – seismic restraints must be separate from isolation mounts.
3. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Type I Restraint: Type FSNTL-SR, Type FN-SR.

D. Type II Restraint

1. All directional, double acting seismic restraint snubber consisting of interlocking steel members restrained by shock absorbent elastomeric material compounded to bridge bearing specifications as indicated elsewhere in this section. Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
2. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
3. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
4. Elastomeric bushing shall be replaceable and a minimum of 1/4-inch- thick. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8-inch- or more than 1/4-inch.
5. The snubber shall be constructed to allow easy inspection of snubber internal clearances.

E. Type III Restraint

1. Cable type system consisting of ASTM A 603 galvanized pre-stretched aircraft type steel cable designed for a minimum safety factor of 2, and end fastening devices, arranged to provide all-directional restraint. End fastening devices, steel assemblies with thimbles, brackets, swivel and bolts designed to swivel and clamp cable with 2 clamping bolts. All

parts of system including cables and clamps, but excluding fastenings, to be furnished by a single vendor to assure seismic compliance.

2. The cable size and attachment to the restrained item and structure shall be designed and signed by a licensed engineer.
3. Submittal drawing shall indicate method of vertical restraint.

F. Type IV Restraint: Nonisolated equipment to be positively attached to structure (powder shots not acceptable) to resist seismic forces.

G. Type V Restraint: Seismic solid brace consisting of steel angles or channels to restrain seismic loads with a minimum safety factor of 2 and arranged to provide all direction (compression, tension and torsion) restraint. Solid brace end connectors shall be assemblies that swivel to the final installation and utilize minimum 2 bolts to provide proper attachment to structure. Provide corrosion resistant coating on all applied hardware.

H. Hanger Rod Stiffener: Hanger rods shall be reinforced to restrain site specific uplift seismic forces.

I. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

J. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

L. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Anchor bolts shall be seismic rated and selected to anchor equipment to building structure. Minimum length of eight times diameter.

M. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Anchor bolts shall be seismic rated and selected to anchor equipment to building structure. Minimum length of eight times diameter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic restraint devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after non conforming code compliance conditions have been corrected.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Provide vibration isolators of appropriate sizes and proper loading to meet specified deflection requirements. Select in accordance with the weight distribution to provide uniform isolator load distribution.

B. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet requirements stated herein, even if not expressly specified or shown on Drawings, without claim for additional payment.

C. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

D. Should any rotating equipment cause excessive noise or vibration when properly installed on the vibration isolators, and if it is caused by isolator, then the isolation manufacturer shall be responsible for rebalancing, realignment or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for unit in question.

E. Make certain that seismic restraints do not short circuit the isolation system and that isolation system is unrestrained. Special attention shall be applied in the installation of restraints on thermally active piping systems as this condition can shorten out vibration isolation devices and impose excessive stress on the structural components.

F. Adjust isolators after piping system is at operating weight.

G. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

H. Adjust active height of spring isolators.

I. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.3 SEISMIC RESTRAINT, APPLICATION

A. General

1. Seismically restrain all specified work in all directions.
2. Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.

B. Equipment

1. Isolated Equipment

a. Suspended Isolated Equipment: Provide four point Type III restraints, up-stop snubbers for vibration isolators and suspension rod stiffener angles or pipe sleeves as required for the following equipment:

1) Fans
2) Terminal Boxes

b. Other Isolated Equipment: Mount equipment on rigid steel frame unless the equipment manufacturer certifies direct attachment capability. Provide a minimum of four Type I or Type II Restraints. Locate Type II restraints as close to the vibration isolator as possible to facilitate attachment to the base and the structure. At option of Contractor, provide Unit RIRS where applicable.

2. Rigidly Mounted Non-isolated Equipment

a. Provide four point Type III or Type V restraints for overhead suspended equipment. For other equipment, provide Type IV restraints using properly sized anchor bolts.

3. Internally Isolated Equipment

a. Manufacturer and supplier of seismic restraints assumes responsibility of meeting seismic requirements and must submit in writing, certification that equipment meets all applicable codes and site specific seismic restraint design requirements, signed and stamped by a registered engineer in the state where the project is located.

4. Supplementary Restraints, Isolated and Non-isolated Equipment

a. Where base anchoring for heavy equipment and for high center of gravity equipment is insufficient to resist seismic anchoring forces, provide four point Type III restraints, connected above center of gravity, as required to suitably restrain the seismic overturn anchoring forces. The need for such additional restraints shall be determined by the isolation manufacturer.

5. Diffusers, registers and grilles installed in ceilings must meet seismic requirements of ceiling by using earthquake clips secured to T-bar structure or 4 point Type III restraint.
6. Air volume control boxes rigidly connected to ductwork and with a Seismic Design Category component Importance Factor of Ip=1.0 is exempt from seismic restraint. Air volume control boxes with an Ip=1.5 and weighing more than 26 pounds shall be provided with 4 point Type III restraints.
7. Fans, heat exchangers, humidifiers and other suspended equipment in ductwork greater than 75 pounds (34 kg) must be independently restrained.

C. Unrestrained Ceiling Systems

1. Connections to all equipment, devices, fixtures, grilles, registers, diffusers and other appurtenances mounted in the ceilings shall be flexible so that they do not restrict the movement of the unrestrained ceilings. The ceilings must be "free-floating" and the flexible connections must allow for a minimum free movement of the ceiling system of 3/8 inch in all directions.

2. Allow for ceiling movement at rigid penetrations through ceiling tiles such as ductwork and piping by providing an oversized opening in the ceiling tile. Provide suitable escutcheons or closure details to cover gaps from view.
3. Each individual device shall be independently supported from building structure in accordance with the applicable code.

D. Piping and Ductwork

1. Piping restraints shall comply with requirements in MSS SP-127.
2. Provide Type III restraints for isolated piping in mechanical rooms. Type III or Type V seismic restraints for non-isolated piping. All other piping 2-1/2 inch (DN 65) diameter and larger, provide Type III restraints for isolated piping and Type III or Type V restraints for non-isolated piping. Provide up-stop snubbers for vibration isolators and suspension rod stiffeners as required.
3. Transverse bracing on runs of piping not to exceed a spacing of 10 feet on no-hub piping; transverse bracing on runs of other piping up to size 16 inches (DN 400) not to exceed 40 feet; piping 18 inch (DN 450) to 28 inch (DN 700) not to exceed 30 feet, piping 30 inch (DN 750) to 40 inch (DN 1000) not to exceed 20 feet; at all changes in direction of more than 4 feet.
4. Longitudinal bracing at 20 feet intervals on no-hub piping; longitudinal bracing of other piping at intervals of 80 feet on piping size up to 16 inches (DN 400), 60 feet on piping size 18 inch (DN 450) to 40 inch (DN 1000).
5. Bracing distances for multiple pipe runs on the same support must be calculated by isolation manufacturer.
6. Hold-down clamps must be used to attach pipe to all trapeze hangers prior to installing restraint. Clamps or restraints must not impede thermal expansion or contraction of piping system.
7. Branch piping is not an acceptable means for restraining main piping.
8. Provide Type III or Type V seismic restraints for rectangular ductwork with cross sectional area of 6 square feet (0.5 square meters) or larger, and for round ductwork 28 inches and larger.
9. Transverse bracing on runs of ductwork not to exceed 30 feet; longitudinal bracing at 60 feet intervals; provide bracing at all changes in direction of more than 4 feet.
10. Provide additional duct reinforcement consisting of steel angle on top of ductwork attached to hanger at restraint locations. Ductwork is to be attached to both upper angle and lower trapeze.
11. All high hazard and life safety systems regardless of size such as fuel oil or gas shall be seismically restrained. Provide Type III restraints for isolated piping and Type III or Type V restraints for non-isolated piping.

E. Electrical Equipment and Conduit: Restrain electrical equipment and conduit provided under Division 23 as specified for mechanical equipment and piping.

3.4 SEISMIC RESTRAINTS, INSTALLATION

A. General

1. Install restraints in strict accordance with applicable site specific seismic codes and design parameters and the isolation manufacturer's written instructions. Whenever a conflict occurs, the most stringent shall apply.

2. Comply with requirements in Division 07 for installation of roof curbs, equipment supports, and roof penetrations.
3. Positively attach restraints to the building structure and to the equipment, piping and ductwork in accordance with the reviewed submittal data.
4. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and anchor equipment to base and building structure.
5. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

B. Equipment Restraints

1. Construct housekeeping pads in accordance with site specific design parameters for anchoring the equipment to the concrete pad with proper edge distances.
2. Restraints shall not interfere with the performance of the vibration isolation system and shall not restrict normal vibratory movement of equipment, piping or ductwork during normal operation, startup or stopping. Install carefully and adjust carefully after system startup and with equipment in operation to insure that proper clearances are maintained.

C. Where restraints are attached to clevis hangers, provide cross bolt reinforcement.

D. Shim or grout snubbers as required to achieve and maintain clearance.

E. Anchor restraints to building structure by field bolting or welding. Overstress of the building structure must not occur. Do not support overhead supported equipment from slab diaphragms between beams unless specifically approved. Restraint anchoring is allowed to the following building structures:

1. Flanges of structural steel beams
2. Cast-in-place inserts or drilled in mechanical type anchor, Hilti or equal, in concrete. Shot pins and adhesive type anchors are not allowed.

F. Install Type III restraints with slack as required, 1/2 inch maximum, to prevent excessive seismic motion for vibration isolated systems and equipment and to allow for thermal movement where applicable. Install Type III restraints taut elsewhere. Provide two sided, seismically rated, beam clamps when securing to steel structural members.

G. Contractor shall notify special inspection agency/engineering consultant 48 hours in advance of work being completed for required special inspections. Contractor shall cooperate with and shall provide free access to work for the special inspection agency/engineering consultant.

3.5 VIBRATION ISOLATION, APPLICATION

A. General

1. The static deflections of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment

1. Unless otherwise shown or specified, set all floor mounted major equipment on 4 inch high housekeeping type concrete pad properly doweled or bolted to floor to meet site specific anchoring forces. Size pad to extend far enough beyond restraint to develop full rating of restraint in accordance with isolation manufacturer's instructions.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as specified in the "Design Requirements" article in Part 1 of this section.
3. Provide thrust restraints on equipment as called for in the schedule or as specified or as required whether or not scheduled or specified to limit movement to 1/4 inch maximum. As a minimum, provide thrust restraints for all suspended fans, all suspended or floor mounted axial flow fans and for other floor mounted fans developing 4 inches or more static pressure, unless the horizontal component of the thrust force can be demonstrated to be less than 10% of the equipment weight. Install thrust restraints on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable.

C. Ductwork

1. Isolate all sheet metal ducts and air plenums within mechanical rooms or within a distance of 50 feet total duct length of connected vibration isolated equipment (whichever is longer) from the building structure by either Type FN, PCF or HN isolators (whichever is applicable to mounting condition). All isolators shall achieve not less than 0.1 inch static deflection.
2. Isolate ducts within the specified limits that penetrate nonfire-rated building construction from the building by use of resilient penetration sleeve/seals.
3. Use resilient lateral supports wherever lateral support of vertical duct runs is required within the specified areas.

3.6 VIBRATION ISOLATION, INSTALLATION

A. General

1. Select locations of all vibration isolation equipment for ease of inspection and adjustments, as well as for proper operation.
2. Install vibration isolation equipment in accordance with isolation manufacturer's written instructions.
3. Prior to startup, verify that there are no isolation short circuits.
4. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Isolators

1. Align all vibration isolators squarely above or below mounting points of supported equipment.
2. Locate isolators for equipment with bases on the side of the bases which are parallel to equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein or shown on the drawings.

4. If a housekeeping pad is provided, isolators and the isolator base plate must rest entirely on pad.
5. For steel framed structures, connect hanger rods for vibration isolated support to structural beams or joists, not to floor slab between beams and joists. Provide intermediate support members and joist reinforcing members as necessary.
6. Position vibration isolation hanger elements as high as possible in hanger rod assembly, but not in contact with building structure, so that hanger housing may rotate a full 360° about rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze which is isolated from building. Deflections must be largest determined by provisions for pipe isolation. Do not hang isolated and nonisolated pipes on same trapeze.
8. Do not support pipes, ducts or equipment from other pipes or equipment.
9. Resiliently isolated pipes shall not contact building construction or other equipment.
10. The installed and operating heights of isolated equipment mounted on Type FSNTL isolators or Type BC-1 bases shall be the same. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 inch clearance between limit stop brackets and isolator top plate, and between travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so isolated equipment is level and in proper alignment with connecting ducts or pipes. Leveling bolts shall not be used to level equipment if unevenness exceeds 1/8 inch as measured by the longest dimension of the equipment base. If leveling of equipment requirements are greater than 1/8 inch, grouting of the base shall be used in order to achieve a level equipment mounting platform.

C. Bases

1. Equipment shall not bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by equipment manufacturer. This provision applies whether or not a base frame is called for on the schedule. In the case that a base frame is required for equipment because of equipment manufacturer's requirements and a base frame for the equipment is not specifically called for on equipment schedule, Contractor for DIVISION 23 shall provide the base frame recommended by equipment manufacturer at no additional expense.
2. Unless otherwise indicated, there shall be a minimum operating clearance of 1 inch between steel rails, steel frame bases or inertia bases and the concrete housekeeping pad or floor beneath the equipment. Position isolator mounting brackets so that required clearance is maintained. Check and clean clearance space to ensure that no construction debris has been left to short-circuit or restrict proper operation of vibration isolation system.

D. Vibration Isolation Thrust Restraints: Attach thrust restraints at the vertical centerline of thrust on each side of the unit, and so that thrust rods are in tension only. Install the two rods of the thrust restraint parallel to the thrust force. This may require modified brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Adjust restraints to constrain equipment movement to the specified limit.

E. Resilient Penetration Sleeve/Seals: Install penetration seals to maintain an airtight seal around penetrating element and to prevent rigid contact of penetrating element and building construction. Fit sleeve tightly to building construction and seal airtight on both sides of construction penetrated with acoustical sealant.

F. Grommets: Where grommets are required at hold-down bolts of isolators, properly size bolt holes to allow for grommets. The hold-down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized for galvanized isolators and stainless steel elsewhere.

3.7 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install seismically rated flexible connections in piping where they cross building seismic expansion joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping Systems" for piping flexible connections.

3.8 FIELD QUALITY CONTROL

A. Upon completion of installation of all vibration isolation devices, the isolation manufacturer's representative shall inspect the installation and certify in writing to the Contractor that all isolation devices are installed in compliance with the written quality assurance document as furnished by the isolation manufacturer.

B. All independent Special and Periodic Inspections must be performed and submitted on components as outlined in Part 1 of this Section.

END OF SECTION 23 05 48

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. HVAC Piping Insulation
2. HVAC Duct Insulation
3. HVAC Equipment Insulation
4. Adhesives, mastics, tapes
5. Recovering

B. Related Sections

1. Pipe insulation insert and shields are specified in Section 23 05 00, "Common Materials and Methods For HVAC".

1.3 DEFINITIONS

A. Cold Surfaces: Normal operating temperatures less than 75° F.

B. Density: Is expressed in pcf (pounds/cu. ft.) (kg/m3).

C. Dual Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

D. Hot Surfaces: Normal operating temperatures of 100° F or higher.

E. Thermal Conductivity ("k" value): Measure of heat flow through a material at a given temperature difference; conductivity is expressed in units of (Btu x inch)/(h x sq. ft. x ° F) (W/m x °C).

F. Through Resistivity ("R" value): Represents the reciprocal of thermal conductivity ("k" value).

1.4 REFERENCES

A. ASTM C 1136 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

B. ASTM E 84 Surface Burning Characteristics of Building Materials.

C. MICA Standards: National Commercial & Industrial Insulation Standards published by the Midwest Insulation Contractors Association. Endorsed by National Insulation Contractors Association (NICA) and its regional associations.

D. NFPA 90A Installation of Air Conditioning and Ventilating Systems.

E. NFPA 255 Test of Surface Burning Characteristics of Building Materials.

F. UL 723 Surface Burning Characteristics of Building Materials.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, as applicable).

B. Product Schedule or List: Prepare a summary of products required and clearly indicate location of their intended use.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

1.6 QUALITY ASSURANCE

A. Materials, job conditions and installation shall be in compliance with the applicable Building and Mechanical Codes and NFPA 90A.

B. Installation shall be done in a workmanlike manner by skilled and experienced workers who are regularly employed in commercial/industrial insulation work, in accordance with manufacturer's recommendations and instructions and best practices of the trade.

C. Comply with the more stringent of the requirements of this specification or the requirements of the MICA standards.

D. Insulation materials manufacturing facilities must be certified and registered with an approved registrar for conformance with ISO 9000 quality standard.

E. Fire Performance Characteristics

1. Insulation, jacketing materials, PVC covers, tapes, adhesives, mastics, cements and finish coatings shall have a composite noncombustible fire and smoke hazard rating and label, as tested in accordance with United States Public Health Service requirements, ASTM E 84, NFPA 255 and UL 723 not exceeding Flame Spread 25 and Smoke Developed 50.
2. Indoor Recovering Canvas Jackets: UL listed fabric, 6 ounce per square yard (203 g/m2), unless otherwise specified, attached with a lagging fire retardant and waterproof adhesive.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature. Deliver materials to job site in original nonbroken factory packaging, labeled with manufacturer's density and thickness and store in a safe, dry place.

B. No insulation material shall be installed that has become damaged in any way.

C. Do not install, and remove from the site, any insulation material that has become wet because of transit or job site exposure to moisture or water. Remove insulation from ductwork, piping and/or equipment which has become wet. Reinsulate as required.

1.8 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Common Materials and Methods for HVAC."

B. Coordinate clearance requirements with installing contractor for insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.9 SCHEDULING

A. Schedule insulation application after pressure testing of piping and duct systems. Insulation application may begin on segments that have satisfactory test results.

B. Schedule insulation application on chilled water piping prior to circulating chilled water and schedule application on supply air ductwork prior to delivering conditioned air. Do not install insulation to surfaces where condensation is present.

C. Do not install any insulation before building is adequately closed in. Where it is necessary to install insulation in any section of building that is not adequately closed in, secure prior permission and, where permission is granted, such insulation shall be in place to form a waterproof covering. Remove and replace all insulation installed that becomes water saturated because of failure to comply with this requirement, at no increase in the Contract sum.

1.10 ALTERNATIVES

A. Alternative insulations are subject to Architect's approval. Alternatives shall provide, at normal conditions, thermal resistance within 5% of resistance of materials specified.

B. Where alternative thermal conductivity ("k") differs from specified thermal conductivity by more than 5%, increase or decrease insulation thickness as follows:

$$\text{New Thickness} = \frac{\text{Actual "k"}}{\text{Specified "k"}} \times \text{Specified Thickness}$$

PART 2 - PRODUCTS

2.1 PIPING INSULATION

A. Acceptable Manufacturers

1. Johns Manville
2. Armacell
3. Owens-Corning Fiberglass
4. Knauf Insulation
5. Certain Teed

B. Insulation Type P1:

1. Piping: Fine fibrous glass insulation, with factory applied vapor barrier jacket, molded to conform to piping, "k" value at 75° F maximum 0.23 (0.033). Johns Manville "Micro-Lok AP-T Plus" with jacket of white Kraft reinforced with fiberglass yarn and bonded to aluminum foil, and having a pressure sensitive tape closure system bonded to the longitudinal lap.
2. Valves and Fittings:

   a. Glass fiber insert of equal thickness to adjacent pipe insulation and premolded PVC cover, Johns Manville "Zeston" and "Hi-Lo Temp Inserts" for valves and fittings.
   b. Factory molded fibrous glass fitting covering for fittings of equal thickness to adjacent pipe insulation. Cover with 6 ounce (170 g) canvas on concealed piping and 8 ounce (227 g) canvas on exposed piping.
   c. Mitered sections of pipe covering for valves.

C. Insulation Type P2:

1. Piping: Type P1 with additional aluminum jacket of Alloy No. 5005 or No. 3003 with minimum thickness of 0.016 inches. Johns Manville "Micro-Lok ML".
2. Valves and Fittings: Mitered sections of Type P2 piping insulation with miter seals and snap-straps.

D. Insulation Type P3:

1. Piping: Foamed plastic of closed cell structure, "k" value at 75° F maximum 0.25 (0.035). Maximum water vapor transmission rating of 0.05 perms (2.87 ng/s-m^2-Pa). Insulation shall not drip or melt when exposed to flame. Polyethylene or polyolefin not allowed. Armacell "AP Armaflex", "AP Armaflex SS" and "AP Armacell W" (maximum 0.2 perms). Exposed insulation in finished areas shall be white.
2. Valves and Fitting: Mitered sections of Type P3 insulation. Factory produced or field fabricated.

2.2 EQUIPMENT INSULATION

A. Acceptable Manufacturers

1. Johns Manville
2. Armacell
3. Owens Corning
4. Knauf

B. Insulation Type E1 - Cold Equipment: Rigid fibrous glass insulation, density approximately 4.25 pcf (68 kg/m^3), with factory applied reinforced aluminum foil vapor barrier, "k" value at 75° F maximum 0.23 (0.033). Johns Manville "815 Spin- Glas" with FSK jacket.

C. Insulation Type E2 - Hot Equipment Up to 350° F: Rigid fibrous glass insulation, density approximately 4.25 pcf (68 kg/m^3), with factory applied reinforced aluminum foil vapor barrier, "k" value at 75° F maximum 0.23 (0.033). Johns Manville "815 Spin-Glas" with FSK jacket.

D. Insulation Type E3L - (and E3H) Hot Equipment Up to 1200° F: Asbestos free hydrous calcium silicate, "k" value at 200° F and 500° F maximum 0.42 (0.06) and 0.50 (0.072) respectively. Johns Manville "Thermo-12 Gold". Flat, pipe, scored block or radius shape to suit equipment shape.

E. Insulation Type E4 – Cold Equipment: Foamed plastic of closed cell structure, "k" value at 75° F maximum 0.25 (0.035). Maximum vapor transmission rating of 0.05 perms (2.87 ng/s-m^3-Pa). Armacell "AP Armaflex Sheet Roll" and "AP Armaflex SA Sheet".

2.3 DUCTWORK INSULATION

A. Acceptable Manufacturers

1. Johns Manville
2. Armacell
3. Owens Corning
4. Knauf
5. Certain Teed

B. Insulation Type D1: Semirigid fibrous glass ductwork and casing insulation, density approximately 6 pcf (96 kg/m^3) with factory applied reinforced aluminum foil vapor barrier, "k" value at 75° F maximum 0.23 (0.033). Johns Manville "815 Spin-Glas" with FSK jacket.

C. Insulation Type D2: Flexible fibrous glass ductwork insulation with factory applied reinforced aluminum foil vapor barrier, density approximately 0.60 to 0.75 pcf (9.6 to 12 kg/m^3), "k" value at 75° F maximum 0.31 (0.045) Johns Manville "Microlite" with Type FSK jacket.

D. Insulation Type D3: Foamed plastic of closed cell structure, "k" value at 75° F maximum 0.25 (0.035). Maximum vapor transmission rating of 0.05 perms (2087 ng/s-m^3-Pa). Armstrong "AP Armaflex" and "AP Armaflex SA".

PART 3 - EXECUTION

3.1 PREPARATION

A. Determine clearances required for installation of work and review such requirements with trades responsible for installing various piping systems, ducts and equipment to be insulated. Where it is

determined that working clearances between equipment and material to be insulated and adjacent work will restrict or prohibit proper installation of work, immediately report such conditions to all interested parties and arrange to have affected material relocated or preinsulated before erection, as approved. Failure to so comply will not relieve Contractor of full responsibility for providing specified insulation.

B. Do not install covering before piping, ductwork and equipment has been tested and approved, or before ductwork has been sealed.

C. Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Comply with applicable requirements of Division 23 Section, "Common Materials and Methods for HVAC".

B. Adhesives and mastics materials shall be compatible with insulation material, jackets and substrates. Apply insulation and adhesives in accordance with manufacturers' instructions.

C. Clean excess adhesive, mastic or cement used in performance of work from all exposed surfaces of insulation jacketing materials. Clean smudges and dirt from all exposed surfaces of insulation jacketing materials at conclusion of this work.

D. Apply insulation on all cold surfaces with a continuous, unbroken vapor seal. Install hangers outside of insulation for all piping subject to sweating (e.g., chilled water supply and return, refrigerant suction, dual temperature water supply and return, drain piping for air conditioning equipment, glycol heat recovery piping, etc.) and provide inserts - refer to and coordinate with Section 23 05 00, Part 3, Article titled "PIPING SYSTEMS – COMMON REQUIREMENTS", paragraph titled "Pipe Insulation Inserts and Shields". For all equipment subject to sweating, insulate and vapor seal hangers, supports, anchors, etc., that are secured directly to cold surfaces to prevent condensation.

E. Extend all surface finishes to protect all surfaces, ends and raw edges of insulation.

F. Install insulation on and at access doors to allow easy use of access door without damage to insulation.

G. Finish insulation neatly at hangers, supports and other protrusions.

H. Install insulation with least number of joints practical. Locate insulation, or cover seams, in least visible locations.

I. Finish installation with systems at operating conditions. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

J. Be responsible for proper curing of insulation, etc., in accordance with manufacturers' requirements.

K. Repair existing insulation damaged through installation of new work to match existing insulation.

3.3 PENETRATIONS

A. Refer to Division 23 Section "Common Materials and Methods for HVAC" for additional requirements.

B. Insulation Installation at Non-Rated Interior Wall and Partition Penetrations: Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Division 07. Coordinate requirements for sleeves and clearance between finished surface of penetrating item and penetrated construction to achieve proper installation of through-penetration fire-stop system.

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Carry pipe insulation through sleeves and through hangers which are specified to be installed outside insulation.

C. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
9. Insulate flexible connections and expansion joints on cold piping with removable insulation section. Install insulation on flanges, valves and unions so that it can be removed and replaced without damaging adjacent insulation.

D. Insulation may be omitted from steam traps, strainers, temperature control valves, safety valves, relief valves, flanges and unions in hot piping 3/4 inch (DN 20) and smaller in size in equipment rooms and 3/4 inch (DN 20) and smaller in size elsewhere. Finish insulation neatly at flanges, leaving space for access to both.

E. Terminate insulation neatly and finish all exposed ends with plastic material troweled on bevel.

F. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

G. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

H. Install insulation at pressure reducing station and steam meter(s) in accordance with steam utility company requirements.

I. Insulation Type P1

1. Seal longitudinal laps of jackets and wrap butt joints with 3 inch wide strip of jacketing material securely sealed in place.

2. Where premolded PVC fitting covers are used, apply factory precut insulation insert in accordance with manufacturer's instructions and then apply one piece cover. Use two or more layers of inserts on hot piping as required to limit outer surface temperatures of insert(s) to 150° F maximum. Use two layers of inserts on chilled water and refrigerant piping. On concealed hot piping, covers may be secured with staples. On exposed hot piping, secure covers by taping ends to adjacent insulation. Seal seam edges of covers on concealed and exposed cold piping with Zeston vapor-barrier adhesive and wrap edges of covers with Zeston vapor-barrier pressure sensitive color matching tape.
3. Where factory-molded fibrous glass fitting covering is used, finish insulation on concealed and exposed hot piping with same jacketing material as adjacent insulation lap-sealed and finished with Foster 30-36, Childers CP-50A or equal. Finish insulation on cold piping same as for hot piping except that sealer shall be Foster 30-35 or Childers CP-30LO vapor sealer.
4. Finish valve covering in hot and cold piping systems same as specified above for fittings.
5. Recover exposed piping in finished areas with 0.02 mil thick PVC jacket and less than 8 ft above floor in equipment room with 0.02 mil thick PVC jacket or aluminum jacket, except use Alpha Assoc. Fiberglass Scrim Fabric "Luben 58" (20 x 10) white, adhered and then finished with Foster 30-36 or Childers CP-50A at steam pressure reducing stations and when piping systems are specified to be painted.

J. Insulation Type P2

1. Secure metal jacket in place by a continuous longitudinal friction type joint. Seal circumferential joints with 2 inch wide, .016 inch aluminum preformed snap-strap and clip containing a permanently plastic weatherproof sealant. Where outside diameter of the insulation is over 12-3/4 inches, lock snap-strap in place using 3/4 inch wide, .015 inch (0.381 mm) thick, No. 302 stainless steel bands. Apply snap-strap with appropriate banding wrench.
2. Use mitered sections of metal jacketed insulation for valves and fittings. Seal joints with sealing compound and preformed aluminum bands.
3. Entire installation of metal jacketed insulation shall be weatherproof.

K. Insulation Type P3

1. Where possible, slip insulation over tubing as a full cylinder. Push insulation on to pipe. Do not pull insulation on pipe. Where necessary to longitudinally cut, and at all butt joints, tightly butt edges and join by sealing with waterproof vapor barrier adhesive, Armaflex 520. For Self-Seal type, peel adhesive paper from surface and apply firm pressure along entire longitudinal joint.
2. Cover fittings and valves with equivalent thickness of insulation material.
3. Finish outdoor insulation with two coats of manufacturer's recommended weather-resistant and ultraviolet-resistant protective finish: Armacell WB Armaflex, white. DO NOT TINT FINISH.

    a. At Contractor's option (for all outdoor piping), use aluminum jacket, as specified for insulation Type P-2.
    b. Secure metal jacket in place by a continuous longitudinal friction type joint. Seal circumferential joints with 2 inch wide, .016 inch aluminum preformed snap-strap and clip containing a permanently plastic weatherproof sealant. Where outside diameter of the insulation is over 12-3/4 inch, lock snap-strap in place using 3/4 inch wide, .015 inch thick, No. 302 stainless steel bands. Apply snap-strap with appropriate banding wrench.

c. Use mitered sections of metal jacketed insulation for valves and fittings. Seal joints with sealing compound and preformed aluminum bands.
d. Entire installation of outdoor piping shall be weatherproof.

3.5 PIPING INSULATION SCHEDULE

Service Temp	Systems Description	Indoor			Outdoor or Unheated Space			
		Type	Pipe Size	Thick-ness	Type	Pipe Size	Thick-ness	Heat Trace
40-60F	Chilled Water	P1 or P3	≤ 3/4"	1"	P2 or P3	≤ 3/4"	2"	Yes
			1" to 1 1/2"	1 1/2"		1" to 1 1/2"	2 1/2"	
			≥ 2"	2"		≥ 2"	2 1/2"	
40-60F	Condensate Drain (Cooling Coil, Heat Recovery Coil, Heat Pump)	P1 or P3	≤ 1 1/4"	1/2"	P3	All	2"	Yes
			≥ 1 1/2"	1"				
140-200F	Heating and Reheat Hot Water	P1	≤ 1 1/2"	1 1/2"	P2	All	2 1/2"	Yes
			≥ 2"	2"				
140-200F	Steam Condensate (Gravity, Pumped, Transfer)	P1	≤ 1 1/2"	1 1/2"	P2	All	2 1/2"	Yes
			≥ 2"	2"				
140-200F	Steam Vent (except safety relief vents)	P1	All	1/2"	-	-	-	
<250F	Low Pressure Steam (25 psig and below)	P1	≤ 3/4"	1 1/2"	P2	≤ 3/4"	2 1/2"	
			1" to 6"	3"		1" to 6"	4"	
			≥ 8"	3 1/2"		≥ 8"	4 1/2"	

Note:
1. Insulation for underground piping systems is specified in Section 23 24 13.
2. Outdoor or Unheated Space insulation thickness shall extend through wall inside the building or heated space minimum of 2 ft.
3. Insulation can be omitted from Condenser Water System located indoors in mechanical rooms and in spaces within buildings that are not humidified only when approved by Architect/Engineer.
4. Where systems are required that don't exactly match the systems description listed on the schedule, provide insulation based on the appropriate service temperature range.

3.6 DUCTWORK AND CASINGS INSULATION INSTALLATION

A. Penetrations Through Construction:

1. Except at penetrations through fire or smoke rated construction, ensure that insulation is continuous through floors, walls and partitions. Where duct is enclosed in a fire rated shaft, carry insulation through penetration of intermediate floors in shaft.

2. Omit insulation on portion of duct passing through fire rated construction. Terminate insulation at each face of construction. Provide appropriate vapor seal at termination for ductwork subject to condensation.

B. Insulation Type D1:

1. Apply with edges tightly butted. Impale on pins welded to duct and secure with speed clips. Cut protruding ends of pins flush. Space pins as required to hold insulation firmly in place but not less than one pin per square foot. Seal all joints, exposed ends, speed clips and penetrations of the vapor barrier with minimum 3 inch wide strip of the vapor barrier material applied with Foster 85-75 or Childers CP-82 to both surfaces or with pressure sensitive tape to match facing.
2. Outdoor Installation: Cover with sheet metal jacketing; minimum 26 gauge (0.55 mm) aluminum in conformance with ASTM B209M, having lock forming corner bead and joint capability. Interlocking seams and corner beads completely sealed and made water tight.

C. Insulation Type D2

1. Cut insulation to length longer than duct perimeter to minimize compression and maximize installed "R" value as recommended by manufacturer. Allow maximum fullness at corners of rectangular ductwork and avoid excessive compression.
2. Insulation shall be firmly butted at all joints with a maximum allowable compression of 25%. Secure insulation to underside of ducts 18 inches or greater in width with mechanical fasteners welded to duct and speed clips spaced approximately 18 inches on center. Cut protruding ends of pins flush. Additionally secure to sides of ducts 18 inches or greater in depth and to the two larger sides of all vertically installed ductwork with mechanical fasteners in the same fashion as for the underside of ducts 18 inches or greater.
3. Overlap all joints at least 2 inches and staple in place. Seal stapled seams, speed clips and breaks in the vapor barrier facing with a minimum 3 inch wide pressure sensitive tape designed for use with the duct insulation. Use pressure sensitive tape and apply additional Foster or Childers sealant in concealed spaces to provide a complete sealed thermal break installation.

D. Insulation Type D3

1. Verify that horizontal rectangular ductwork is properly pitched to avoid ponding before installing insulation.
2. Install using manufacturer's recommended adhesive (Armacell Armaflex 520). Metal surface must be clean and dry before application. Use full adhesive coverage attachment, including seams and joints. Coat both surfaces to be joined. Apply pressure to the surface of the insulation to assure a tight bond. Make sure all joints are under compression.
3. Install on each surface and butt joint at corners. Do not continuously wrap around corners on rectangular duct causing insulation to be in tension.
4. Outdoor Installation: Finish, using manufacturer's recommended procedures, with two coats of manufacturer's recommended weather-resistant and ultraviolet-resistant finish (Childers Vi-Cryl CP-10 white, with elastic reinforcing cloth (Vimasco Dynel Elastafab #894 8 x 8 mesh) blended into the first coat. DO NOT THIN THE MASTIC. Overlap seams of reinforcing cloth a minimum of 6 inches at each corner of rectangular ductwork. Completely cover mesh with second coat, applied immediately after the first coat has taken its set.

E. Insulation Type D4

1. Secure with No. 16 gauge galvanized annealed steel wire for small areas and No. 12 gauge stainless steel annealed steel wire or 1/2 inch x 0.15 inch aluminum or stainless steel band on 12 inch maximum centers for large areas. Where required, provide welded studs, clips or angles as anchors for wires and bands.
2. Tightly stretch 1 inch hexagonal mesh in place over insulation and secure by wiring to anchors, with edges tied together. Reinforce corners with corner bead. Finish with hydraulic Insulating and Finishing Cement or approved equal applied 1/4 inch thick in 1 coat, troweled to smooth finish.

F. Insulation Type D5

1. Apply with edges tightly butted. Impale on pins welded to duct and secured with speed clips, located and spaced as recommended by manufacturer to prevent sagging, but not less than one pin per square foot. Secure with 3/4 inch wide, minimum 0.015 inch thick aluminum or stainless steel bands, spaced as recommended by manufacturer, but not more than 12 inch maximum centers. Where required, provide welded studs, clips or angles as anchors for bands. Cut protruding ends of pins flush and seal with tape patch.
2. Tightly stretch 1 inch hexagonal mesh in place over insulation and secure by wiring to anchors, with edges tied together. Reinforce corners with corner bead. Finish with an all purpose (AP) jacket. Seal all joints with 3 inch wide strip of matching material applied with Foster 85-75 or Childers CP-82 to both surfaces or with pressure-sensitive tape to match jacket.

G. Insulation Type D6: Install in strict accordance with terms of the UL listing and the manufacturer's instructions, including insulation of hanger system.

3.7 DUCTWORK AND CASING INSULATION SCHEDULE

A. Minimum Thickness

1. Insulation thickness indicated hereinafter in this article and/or on the drawings is minimum thickness. Where duct is constructed with flanged, angle, standing, factory fabricated or similar joints or reinforcing, increase thickness to provide minimum 1/4 inch cover on edge of joint or reinforcing.
2. Increased thickness section shall be a minimum of 6 inch inches wide, centered on flange or reinforcing with exposed ends sealed as specified in this article for concealed ductwork. Increase thickness throughout entire length of duct to provide a uniform thickness and appearance for all exposed ductwork.

B. Type

1. Exposed Indoor Rectangular Ductwork - Type D1.
2. Concealed Rectangular Ductwork - Either Type D1 or Type D2 at Contractor's option.
3. Apparatus and Equipment Casings – Type D1 Indoors, Type D3 Outdoors
4. Indoor Round and Oval Ductwork - Type D2.

C. Thickness Schedule

Location	Thickness* Type D1 and D3	Thickness* Type D2
1. Equipment Casing		
a. Indoor (Type D1)	2 Inches	Not Allowed
b. Outdoor (Type D3)	3 Inches	Not Allowed
2. Ductwork Location		
a. Outdoors		
1) Supply air	3 Inches	Not Allowed
2) Return air	3 Inches	Not Allowed
3) Exhaust air	1-1/2 Inches	Not Allowed
b. Indoors (Type D1 or D2)		
1) Air Conditioning Supply and Return Between Roof and Suspended Ceiling	1-1/2 Inches	2 Inches
2) Shaft with Exterior Wall	1-1/2 Inches	2 Inches
3) Other Than Above	1 Inch	1-1/2 Inches

*Subject to compliance with Paragraph A. of this article, where ductwork or apparatus casing or equipment casing is acoustically lined, reduce insulation thickness by equivalent thickness of lining so that combined "R" of lining and insulation is equal to or greater than "R" of specified insulation thickness. Increase thickness at flanged or standing joints to provide minimum 1/4 inch cover over edge of flange or joint.

D. Listing of Ductwork and Casings to be Insulated:

1. All air conditioning system supply air ductwork, casings and plenums.
2. Air conditioning system return air ductwork, casings and plenums located in:
   a. Mechanical equipment room and penthouse.
   b. Ceiling space or plenum where there is roof above.
   c. Shaft with exterior wall(s) or shaft passing through non-air conditioned space.
   d. Non-air conditioned space, including shaft not surrounded by air conditioned spaces on all sides and ceiling space or plenum with non-air conditioned space either above or below.
3. Fire damper, smoke damper, combination fire and smoke damper sleeve for damper installed in acoustically lined ductwork. Insulate only the portion not within the penetrated construction.
4. Air conditioning system return air ductwork, casings and plenums located outdoors.
5. Casings of heating and air conditioning systems and equipment which are not factory insulated, including plenums (supply, return, mixing), filter sections, access sections, sound attenuator casings and all other areas subject to condensation, heat gain or heat loss.
6. Flexible ductwork not factory insulated.
7. Heating and ventilating system return ductwork located in crawl space, attic or other nonheated spaces, including shaft with exterior wall, ceiling space or plenum with roof above or with either nonheated space above or below.
8. Heating and ventilating system supply ductwork, except ductwork exposed in spaces heated by the system.

9. Reheat coil sections of air volume control boxes. Extend insulation minimum of 4 inches upstream and downstream of coil connection.
10. Supply air diffuser plenums/back pans that are not either insulated or acoustically lined at the factory.
11. Ductwork and casings shown on the Drawings to be insulated, whether or not listed above.

3.8 EXISTING INSULATION

A. Repair existing pipe and ductwork insulation damaged through installation of the new work or alterations or connections to existing work. Match insulation material, thickness and method of application with existing.

END OF SECTION 23 07 00

SECTION 23 21 13 - HYDRONIC PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Pipe, valves and fittings
2. Strainers
3. Hydronic System Specialties and Accessories
4. Flow Meters
5. Expansion Joints and Guides

1.3 PERFORMANCE REQUIREMENTS

A. Design working pressure and temperature for all specialties and accessories suitable for system operating temperature and pressure 125 psig (863 kPa) at 225° F minimum except as noted below.

B. Base expansion calculations on 50° F installation temperature to 210° F for hot water heating, plus 30% safety factor.

1.4 SUBMITTALS

A. Product Data: For each type of factory fabricated item indicated, include pressure ratings, construction materials, data sheets, performance characteristics, and furnished accessories.

B. Field quality-control test reports.

C. Grooved joint couplings and fittings shall be shown on the drawings and product submittals, and shall be specifically identified with the applicable style or series designation.

1.5 MANUFACTURER'S SUPERVISION/INSPECTION SERVICE

A. Expansion Joints, Offset Type: Provide service of manufacturer's authorized representative to inspect installation and to submit report of his inspection to Architect.

B. Flexible Pipe: Provide inspection services by manufacturer's representative for final installing and certify installation is in accordance with manufacturer's recommendations and that connectors are performing satisfactorily.

C. Grooved Installations: The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

E. Conform to Standards of Expansion Joint Manufacturer's Association.

F. All grooved joint couplings, fittings, valves and specialties shall be products of a single manufacturer. Grooving tools shall be of same manufacturer as the grooved component.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22 for pressure fittings, ASME B16.29 for drainage fittings.

E. Cast Brass Fittings: ASME B16.18 for pressure fittings, ASME B16.23 for drainage fittings.

F. Flanges for Copper Tubing: Cast Bronze, ASME B11.24, Classes 150 and 300, solder joint.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type E, Grade B (electric resistance welded), wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Threaded Unions: ASME B16.39; Class 250 as indicated in Part 3 "Piping Applications" Article.

E. Unions in Welded Steel Pipes 2 Inches (DN 50) and Smaller: Class 3000 carbon steel socket welding union steel to steel seat and ground joint. Stainless steel in stainless steel piping.

F. Welded Fittings for Black Steel Pipe 2 Inch (DN 50) and Smaller: Forged steel socket welding fittings. ASTM A105 and ASME B16.11, wall thickness to match adjoining pipe. All elbows long radius.

G. Welding Fittings for Black Steel Pipe 2-1/2 Inch (DN 65) and Larger: ASTM A234/A234M and ASME B16.9, wall thickness to match adjoining pipe. All elbows long radius.

H. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

I. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

J. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts and nuts in accordance with applicable ASME standards. Flanges to be of slip-on, weld neck, threaded or solder type to suit piping system in which installed.

K. Steel Pipe Nipples: ASTM A 733, made of same materials as pipe in which they are installed, Schedule 80.

2.3 VALVES, GENERAL REQUIREMENTS

A. Valves are specified by valve type. Where more than one valve type is listed for a service, use any of the listed types, unless otherwise specified or indicated, but selection must be consistent throughout the work.

B. Bronze Valves: NPS 2 (DN 50) and smaller with solder or threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
2. Handwheel: For valves other than quarter-turn types.
3. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller, except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Extended Valve Stems: On insulated valves.

H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

I. Valve Grooved Ends: AWWA C606.

J. Solder Ends: With sockets according to ASME B16.18.

1. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves. For ball valves and calibrated orifice balancing valves, manufacturers shall verify that valve construction is satisfactory for use with non-lead solders.

K. Threaded Ends: With threads according to ASME B1.20.1.

L. Valve Bypass and Drain Connections: MSS SP-45.

M. Automatic Temperature-Control Valves, Actuators and Sensors: Comply with requirements specified in Division 25 Section "Instrumentation and Control for HVAC".

2.4 BRONZE ANGLE VALVES

A. Acceptable Manufacturers:

1. Type 2, Bronze Angle Valves:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves
c. Milwaukee Valve Co.
d. Powell, Wm. Co.

B. Bronze Angle Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 150, Bronze Angle Valves: Bronze body with PTFE disc and union-ring bonnet. Dezincification-resistant bronze body, Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61. Forged or yellow brass bodies will not be accepted. NIBCO T-335-Y.

D. Type 2, Class 300, Bronze Angle Valves: Bronze body with regrinding seat and union-ring bonnet. Dezincification-resistant bronze body, Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61. Forged or yellow brass bodies will not be accepted. NIBCO T-375-B/Y; T-376-AP.

2.5 CAST-IRON ANGLE VALVES

A. Acceptable Manufacturers:

1. Type II, Cast-Iron Angle Valves with Metal Seats:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Milwaukee Valve Co.

B. Cast-Iron Angle Valves, General: MSS SP-85, Type II.

C. Class 125, Cast-Iron Angle Valves: Bronze mounted with gray-iron body and bronze seats. NIBCO F-818-B.

2.6 COPPER-ALLOY BALL VALVES

A. Acceptable Manufacturers:

1. Two-Piece, Copper-Alloy Ball Valves, NIBCO, Inc., series listed, or equivalent product manufactured by:

   a. Conbraco Industries, Inc.; Apollo Div.
   b. Crane Co.; Crane Valve Group; Crane Valves
   c. Jamesbury, Inc.
   d. Milwaukee Valve Company
   e. Watts Industries, Inc.; Water Products Div.
   f. Worcester

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Bronze body with full-port, chrome-plated bronze ball; TFE seats and packing; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem. Dezincification-resistant bronze body, Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61, ball and/or trim. Forged or yellow brass bodies will not be accepted. NIBCO T-585-70 and S-585-70.

2.7 BRONZE CHECK VALVES

A. Acceptable Manufacturers:

1. Type 1, Bronze, Lift Check Valves with Metallic Disc:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Milwaukee Valve Co.

2. Type 3, Bronze, Swing Check Valves with Metallic Disc:

a. NIBCO, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Milwaukee Valve Company.

B. Bronze Check Valves, General: MSS SP-80. Dezincification-resistant bronze body, Bronze ASTM B584 Alloy C84400 (Solder) or Bronze ASTM B62 Alloy C83600 (Threaded) or Bronze ASTM B61. Forged or yellow brass bodies will not be accepted.

C. Type 1, Class 125, Bronze, Horizontal or Vertical Lift Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 480-Y.

D. Type 1, Class 300, Bronze, Horizontal or Vertical Lift Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 473-B.

E. Type 3, Class 125, Bronze, Swing Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 413-B.

F. Type 3, Class 300, Bronze, Swing Check Valves: Bronze body with metallic disc and bronze seat. NIBCO T/S 473-B.

2.8 SPRING-LOADED, LIFT-DISC CHECK VALVES

A. Acceptable Manufacturers:

1. Type III, Globe Lift-Disc Check Valves:

a. NIBCO, Inc.
b. Metraflex Co.
c. Milwaukee Valve Company.

2. Type IV, Threaded Lift-Disc Check Valves:

a. NIBCO, Inc.
b. Metraflex Co.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty.

B. Lift-Disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.

C. Type III, Class 125, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends. NIBCO F-910-W.

D. Type III, Class 250, Globe Lift-Disc Check Valves: Globe style with cast-iron shell and flanged ends. NIBCO F-960-W.

E. Type IV, Class 125, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends. NIBCO T-480.

F. Type IV, Class 150, Threaded Lift-Disc Check Valves: Threaded style with bronze shell and threaded ends. NIBCO T-480.

2.9 BRONZE GLOBE VALVES

A. Acceptable Manufacturers:

1. Type 2, Bronze Globe Valves with Nonmetallic Disc:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Milwaukee Valve Company.
   d. Powell, Wm. Co.

2. Type 3, Bronze Globe Valves with Renewable Seats:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Milwaukee Valve Company.
   d. Powell, Wm. Co.

B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.

C. Type 2, Class 125, Bronze Globe Valves: Bronze body with PTFE disc and union-ring bonnet. NIBCO T/S 211-Y.

D. Type 3, Class 300, Bronze Globe Valves: Bronze body with renewable stainless steel eats and union-ring bonnect. NIBCO T-276-AP.

2.10 CAST-IRON GLOBE VALVES

A. Acceptable Manufacturers:

1. Type I, Cast-Iron Globe Valves with Reneweable Metal Seats:

   a. NIBCO, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Milwaukee Valve Company.

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with renewable bronze seats. NIBCO F-718-B; F-818-B (Angle).

D. Type I, Class 250, Cast-Iron Globe Valves: Gray-iron body with renewable bronze seats. NIBCO F-768-B; F-869-B (Angle Stop/Check/Globe).

2.11 BRONZE, CALIBRATED-ORIFICE, BALANCING VALVES

A. Acceptable Manufacturers:

1. NIBCO, Inc. (T/S 1710 Globe; S1709 Ball).
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Flow Design Inc.
5. Griswold Controls.
6. Taco.
7. Tour-Anderson; available through Victaulic Company.
8. Nexus Valve

B. Body: Bronze, ball, globe or plug type with calibrated orifice or venturi.

C. Ball: Brass or stainless steel.

D. Plug: Resin.

E. Seat: PTFE or Ametal copper alloy.

F. End Connections: Threaded or solder.

G. Pressure Gage Connections: Integral seals for portable differential pressure meter.

H. Handle Style: Lever, with memory stop to retain set position.

I. CWP Rating: Minimum 125 psig (860 kPa).

J. Maximum Operating Temperature: 250 deg F.

2.12 CAST-IRON OR STEEL, CALIBRATED-ORIFICE, BALANCING VALVES

A. Acceptable Manufacturers:

1. NIBCO, Inc. (F-737 Flanged; G-737 Grooved).
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Flow Design Inc.
5. Griswold Controls.
6. Taco.
7. Tour & Anderson; available through Victaulic Company.

B. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.

C. Ball: Brass or stainless steel.

D. Stem Seals: EPDM O-rings.

E. Disc: Glass and carbon-filled PTFE.

F. Seat: PTFE.

G. End Connections: Flanged or grooved.

H. Pressure Gage Connections: Integral seals for portable differential pressure meter.

I. Handle Style: Lever, with memory stop to retain set position.

J. CWP Rating: Minimum 125 psig (860 kPa).

K. Maximum Operating Temperature: 250 deg F (121 deg C).

2.13 NEEDLE VALVES

A. Acceptable Manufacturers

1. Stockham
2. Nibco
3. Crane
4. Milwaukee

B. Bronze body and stem, working pressure to match piping system in which installed.

2.14 DRAIN AND VENT COCKS

A. Acceptable Manufacturer

1. Ernst Gage Co. or equal.

B. Bronze needle valve, duplex design, repackable stem, male outlet with cap. Service rating 300 psi steam pressure, 500 psi (3450 kPa) at 100° F gas liquid pressure.

2.15 AUTOMATIC FLOW-CONTROL VALVES (AFC):

A. Acceptable Manufacturers:

1. Flow Design Inc.
2. Griswold Controls.

B. Design working pressure and temperature suitable for system operating temperature and pressure, 125 psig (860 kPa) at 225° F minimum

C. Factory calibrated, direct acting, automatic pressure compensating type valve that limits flow rates to within 5% accuracy, regardless of system pressure fluctuations. Valve control mechanism consists of a tamperproof flow element (or an externally accessible flow cartridge) with open chambers and unobstructed flow passages, with a self-cleaning, spring-loaded moving cup guided at two separate points, utilizing the full available differential pressure to actuate without hysteresis or binding. Flow element 100% 304 passivated stainless steel-plated products not acceptable. Provide valve with a metal tag, chain, showing design flow in gpm, line size, pressure drop at design flow and station identification. Include pressure taps and quick disconnect valves. Factory assembled component figurations of AFC and accessories that meet the features specified will be acceptable.

D. End connections to suit character of piping system in which installed. Rated at 400 psig (2760 kPa), 275° F. Brass body for pipe sizes 2 inches (DN 50) and smaller, steel body for pipe sizes larger than 2 inches (DN 50). All internal parts of valve either hard, electroless nickel plated or stainless steel, control mechanism machined from solid brass.

E. Provide portable flow measuring instrument, complete with carrying case, pressure gauge, 3-way valve, hoses and connections. Unit to be compatible with automatic flow control valve.

2.16 PRESSURE/TEMPERATURE TEST PLUGS

A. Acceptable Manufacturers:

1. Peterson Equipment Company, Inc.
2. SISCO

B. Solid brass test plug with cap and seal, Nordel inner core for up to 300° F, extension to suit insulation thickness. Test plug capable of receiving either a pressure or temperature probe 1/8 inch (DN6) O.D. Furnish number of 1/8 inch (DN 6) gauges with adapters and 5 inch stem pocket thermometers for appropriate ranges specified in Warranty and Contract Closeout article of Part 1 of this section. Provide one Master Test Kit containing a 2-1/2 inch test gauge and two 5 inch pocket thermometers.

2.17 AIR CONTROL DEVICES

A. Acceptable Manufacturers:

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Design working pressure and temperature for all specialties and accessories, suitable for system operating pressure and temperature, 125 psig (863 kPa) at 225° F minimum.

C. Air Vent

1. Manual Air Vent: Provide 1/4 inch (DN 8) vent cock.
2. Automatic Air Vent: Float type with isolating valve, brass or cast iron body, copper float, stainless steel valve and valve seat. Suitable for system operating temperature and

pressure. Minimum 3/4 inch (DN 20) inlet for high capacity type, 1/2 inch (DN 15) elsewhere, 1/4 inch (DN 8) outlet.

2.18 STRAINERS GENERAL SERVICE

A. Acceptable Manufacturers

1. NIBCO, Inc.
2. Armstrong Machine Works
3. Hoffman Specialty, ITT
4. Illinois
5. Keckley
6. Mueller Steam Specialty
7. Spirax-Sarco

B. Cast iron (ASTM A 126, Grade B), carbon steel (ASTM A 216, Grade WCB) or brass (ASTM B 62) body as required to meet system pressure and temperature requirements, screwed or flanged ends matching piping in which installed. Provide straight threaded gasket face cap with gasket for screwed end type, cast iron or hot rolled steel cover with gasket for flanged end type and bottom drain connection. Type 304 stainless steel screen unless otherwise required for application with net free area not less than three times the area of the inlet pipe. Maximum 2 psig pressure drop at design flow.

1. Size 2 inch and under, 1/32 inch perforated screen.
2. Size 2-1/2 inch to 4 inch, 3/64 inch perforated screen.

C. Y pattern, except basket pattern in low horizontal piping without sufficient clearance for Y pattern screen removal/replacement.

D. For Stainless Steel Piping: As above except ASTM A 296 cast stainless steel body, 150 psig, flanged Y pattern. Mueller Steam Specialty 761-SS.

E. Gaskets shall not contain asbestos.

2.19 FLEXIBLE CONNECTORS

A. Acceptable Manufacturers:

1. Anaconda
2. Flexonics
3. Korfund
4. Metraflex

B. General: Fabricate of multiple plys of nylon card, fabric and neoprene, vulcanized so as to become inseparable and homogenuous.

C. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.

2. End Connections: 2 inches and smaller threaded; 2-1/2 inches and larger flanged.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F.
6. Maximum unit lengths: 12 inch up to 3 inch (DN 75) size, 18 inch for sizes 4 inch (DN 100) and larger.

D. Provide control rods or cables to control extension of connector.

2.20 EXPANSION JOINTS

A. Acceptable Manufacturers:

1. Metraflex Co.
2. Adsco Manufacturing Corp.
3. Flexonics
4. Keflex, Inc.
5. Hyspan Precision Products Co.

B. General

1. Conform to the standards by Expansion Joint Manufacturers Association. Provide joints with design working pressure to match specified class of valves, flanges and fittings of piping system in which installed and with material of construction suitable for piping system in which installed.
2. Provide joint(s) with rated stroke capable of absorbing 200% of maximum piping expansion at installed location.

C. Bellows Type Externally Pressurized Expansion Compensator for Pipe Sizes 4 Inches and Smaller.

1. 150 psig (1035 kPa) minimum design working pressure, 2 inch rated piping system expansion (refer to Paragraph B.2. above), 1/2 inch rated piping system contraction.
2. For Copper Tubing: Packless all welded and silicon brazed construction, stainless steel housing, internal guide ring, externally pressurized 2-ply stainless steel bellows. Soldered ends for pipe sizes 2 inches (DN 50) and smaller. Factory or field installed soldered to bronze flanged ends for pipe size 2 1/2 inches (DN 65) and larger.
3. For Steel Pipe: Packless all welded construction, carbon steel or stainless steel, internal guide ring, externally pressurized 2-ply stainless steel bellows, internal antitorque device for threaded end models, Pipe sizes 2 inches (DN 50) and smaller welded or threaded ends to match piping system in which installed. Factory or field installed slip-on or weld neck forged steel flanged ends for pipe sizes 2 1/2 inches (DN 65) and larger.

D. Ball Type:

1. Flexible Ball Joints, rated for minimum 200 psig (1380 kPa) at 525° F Service: Carbon steel with weld ends, designed to provide 360° rotation with minimum of 15° angular flexing movement.
2. Furnish with nonmetallic asbestos free mineral filled seals, shall not require the use of sealants or packing.
3. Provide manufacturer's inspection as specified in Part 1 of this section.

2.21 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Acceptable Manufacturers:

a. Advanced Thermal Systems, Inc.
b. Hyspan Precision Products, Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, above ground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
2. Type L (B), drawn-temper copper tubing, wrought-copper fittings, with Press System (press to connect) joints.
3. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints. Nipples Schedule 80.

B. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
2. Type L (B), drawn-temper copper tubing, wrought-copper fittings, with Press System (press to connect) joints.
3. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints. Nipples Schedule 80.

C. Condensate-Drain Piping, NPS 1 (DN25) and smaller shall be any of the following:

1. Type L (B), drawn temper copper tubing, wrought copper fittings, and soldered brazed joints.
2. Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. (Allowed for exposed piping in equipment rooms and underground piping only.)

D. Condensate-Drain Piping NPS 1-1/4 (DN32) and larger, shall be any of the following:

1. Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints
2. Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. (Allowed for exposed piping in equipment rooms and underground piping only.)

E. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 PIPING INSTALLATION

A. Refer to Section 23 05 00, "Common Materials and Methods for HVAC", for general piping installation requirements.

B. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

D. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe. Bull head tees are not allowed.

E. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

3.3 VALVE APPLICATIONS

A. Unless otherwise noted, use the following:

1. Shutoff Service: Ball valves.
2. Throttling or Balancing Service: Angle, ball, butterfly, or globe valves. Butterfly valves not allowed for balancing at pump discharge or for cooling tower balancing service.
3. Pump Discharge: Spring-loaded, lift-disc check valves (non-slam) or triple duty valve.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

D. Install throttling-duty or calibrated-orifice, balancing valves at each branch connection to return main.

E. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

F. Install check valves at each pump discharge and elsewhere as required to control flow direction.

G. Chilled-Water Piping: Use the following types of valves:

1. Angle Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 150, bronze.

2. Ball Valves, NPS 2 (DN 50) and Smaller: Two piece, 600-psig (4140-kPa) CWP rating, copper alloy.
3. Lift Check Valves, NPS 2 (DN 50) and Smaller: Type 1, Class 125, horizontal or vertical, bronze.
4. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 3, Class 125, bronze.
5. Spring-Loaded, Lift-Disc Check Valves, NPS 2 (DN 50) and Smaller: Type IV, Class 125 minimum 150.
6. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.

H. Heating Water Piping: Use the following types of valves:

1. Angle Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 150, bronze.
2. Ball Valves, NPS 2 (DN 50) and Smaller: Two-piece, 600-psig (4140-kPa) CWP rating, copper alloy.
3. Lift Check Valves, NPS 2 (DN 50) and Smaller: Type 1, Class 125, horizontal or vertical, bronze.
4. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 3, Class 125, bronze.
5. Spring-Loaded, Lift-Disc Check Valves, NPS 2 (DN 50) and Smaller: Type IV, Class 125 minimum 150.
6. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.

3.4 VALVE INSTALLATION

A. General

1. Provide valves at locations shown, where specified and where required to properly control piping systems. Provide valves recommended or required by equipment manufacturers and codes for proper operation of equipment and shutoff valves to allow isolation of each main and branch service line, whether or not indicated or specified.
2. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
3. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.
4. Examine threads on valve and mating pipe for form and cleanliness.
5. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
6. Do not attempt to repair defective valves; replace with new valves.
7. Install valves in horizontal piping with stem at or above the center of the pipe.
8. Install valves in a position to allow full stem movement.

B. Check Valves: Provide lift check type after globe valves, install with stem upright and plumb. Provide nonslam type in vertical piping on discharge side of pumps and elsewhere as indicated or specified. Provide horizontal swing check type elsewhere unless otherwise indicated or required for service intended, install in horizontal position with hinge pin level. Install check valves, including those that are spring loaded, so that force of gravity will operate to close valves.

C. Provide valve ends to suit character of pipe in which installed. Provide valves designed for working pressure of at least 125% of maximum operating pressure of system in which installed, but not less than 250 psig (1725 kPa) on high pressure systems, and 125 psig (863 kPa) on low pressure systems.

D. Provide chromium plated valves in chromium plated piping.

E. Plug Valves: Provide 1/4 inch needle valve with nipple and cap at each gauge tap where there is no flow measuring device to measure flow. Otherwise, plug each tap.

3.5 HYDRONIC SPECIALTIES INSTALLATION

A. Air Vents

1. Provide as indicated or required to fully vent air from the system.
2. Provide manual type air vents for fan coil units, and similar equipment.
3. Provide float type, automatic air vents with valved inlet and discharge piped to floor drain for large capacity water coils, as in air handling units, for large piping mains and other major equipment in equipment rooms, and where indicated on Drawings.

B. Pressure/Temperature Test Plugs: Provide nipple as required to locate cap of P/T plug outside of surface of pipe insulation.

C. Relief Valves

1. Provide as required or shown on all water systems and equipment. Aggregate relieving capacity as required by ASME Code.
2. Select system relief valve capacity so that it is greater than makeup pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
3. Pipe relief valve outlet to nearest floor drain.
4. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections. Provide full size service to equipment with reducers at equipment connections.

B. Install control valves in accessible locations close to connected equipment.

3.7 COOLING COIL CONDENSATE DRAIN PIPING

A. Comply with requirements of applicable mechanical and plumbing code.

B. Drain piping for duct mounted steam dispersion coils, built-up cooling coil units and central air conditioning units

C. Provide drain piping for room air conditioning units.

D. Provide water seal traps of sufficient depth to maintain water seal against system static pressure. Enter building drainage system only through an air gap. Run piping to nearest convenient floor drain or as indicated. Pitch at least 1/4 inch per foot (20.8 mm per meter) unless otherwise noted or directed.

E. Provide plugged "TY" at each change in direction and at approximately 60 foot centers on straight runs. Provide cleanout at base of vertical risers as required.

3.8 FLEXIBLE PIPING CONNECTIONS

A. Install where shown, where specified and elsewhere where required. On pipes connected to equipment supported by vibration isolation, install parallel to axis of rotation. Install one end immediately adjacent to the isolated equipment and anchor other end.

B. Flexible piping connections shall not be used to correct misalignment between equipment and connected piping.

C. Except for drainage piping, provide for piping that crosses a building seismic expansion joint in such a manner that building movement cannot be accommodated by pipe offsets or loops.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

C. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure for a minimum of 4 hours with no drop in pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. At the beginning of the pressure test, and periodically during the test, examine piping, joints and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

D. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13