

SECTION 23 05 01

MECHANICAL AND ELECTRICAL COORDINATION

PART 1 - GENERAL

1.1 RESPONSIBILITY

- A. The Divisions 21, 22, 23, 26, 27 and 28 contractor(s) shall comply with the provisions of this section. The Divisions 21, 22, and 23 contractor(s) shall verify electrical service provided by the electrical contractor before ordering any mechanical equipment requiring electrical connections. Provide submittals of all mechanical equipment to Division 26, 27 and 28 contractor(s).
- B. The final responsibility for properly coordinating the electrical work of this section shall belong to the Divisions 21, 22, and 23 System Contractor performing the work, which requires the electrical power.
 - 1. Each Divisions 21, 22, and 23 contractor shall be responsible for providing power wiring for certain devices as described in the specifications and on the drawings. This work shall be provided by a licensed electrician in accordance with all of the applicable provisions of the Division 26, 27 and 28 specifications, NEC and local codes.

1.2 WORK INCLUDED

- A. Carefully coordinate the interface between Divisions 21 through 23 (Mechanical) and Divisions 26 through 28 (Electrical), before submitting any equipment for review or commencing installation.

1.3 DEFINITIONS

- A. **Automatic:** Pertaining to a function, operation, process or device that, under specified conditions, functions without intervention by human operator.
- B. **Disconnect Switch:** A mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from a power source.
- C. **Motor Control Center:** A floor mounted assembly of one or more enclosed vertical sections having a common horizontal power bus and primarily containing motor starting units.
- D. **Control Circuit/Power:** The circuit which carries the electrical signals of a control apparatus or system directing the performance of the controller but does not carry the main power circuit.
- E. **Manual Operation:** Operation by hand without the use of any other power.
- F. MC: Mechanical Contractor = Divisions 21 through 23 Contractor.
- G. TC: Temperature Controls = Division 22, or 23 Contractor who furnishes control.
- H. EC: Electrical Contractor = Divisions 26, 27 or 28 Contractor.
- I. FA: Fire Alarm Contractor = Division 28 Contractor who furnishes Fire Alarm System.
- J. SC: Sprinkler Contractor

K. EP: Electric to Pneumatic Converter.

L. PE: Pneumatic to Electric Converter.

1.4 RESPONSIBILITY SCHEDULE

A. Responsibility: Unless otherwise indicated, all motors and controls for Divisions 21, 22, and 23 equipment shall be furnished, set in place and wired in accordance with the following schedule:

ITEM -	Furnished By	Set In Place By	Power Wiring By	Control Wiring By
Equipment Motors	MC	MC	EC	--
Automatically or Manually Controlled Starters/Contactors: (Note 3)				
-Separate	MC	EC	EC	TC
-Factory Mounted and Wired	MC	MC	EC	TC
Disconnect Switches (Note 1)	EC	EC	EC	--
Thermal Overload Switches (Note 1)	EC	EC	EC	--
Switches (Manual or Automatic other than disconnect) (Note 2)	MC or TC	MC or TC	EC or TC	TC or MC
Control Relays (Note 2)	MC or TC	MC or TC	--	TC
Control Transformers	MC or TC	MC or TC	EC or TC	TC
Thermostat and Controls: Integral with Equipment or Directly Attached to Ducts, Pipes, etc. (Note 2)	MC or TC	MC or TC	MC or TC	TC
Standalone Control Panels (BAS) (Note 5)	TC	TC	TC	TC
Valve Motors, Damper Motors, Solenoid Valves, etc.	TC	TC	TC	TC
Duct System Smoke Detectors (Note 4)	FA	MC	--	TC/FA
Relays for Fan Control via duct detectors (Note 4)	MC	MC	EC	TC
Room Smoke Detectors Including Relays for Fan Control (Note 3)	FA	FA	--	FA
Equipment Interlocks	TC	TC	--	TC
Positive Indication Devices (i.e., current sensors, end switches, airflow sensors)	TC	TC	--	FA/TC (Note 10)

Notes:

1. If furnished as part of factory wired equipment furnished and set in place by MC, wiring and connections by EC. Electrical Contractor shall provide disconnects for all electrical equipment unless otherwise indicated.
2. If float switches, line thermostats, P.E. switches, time switches, or other controls carry the FULL LOAD CURRENT to any motor, they shall be furnished by MC, but they shall be set in place and connected by EC, except that where such items are an integral part of the mechanical equipment, or directly attached to ducts, piping, or other mechanical equipment, they shall be furnished and set in place by MC and connected by EC. If they do not carry the FULL LOAD CURRENT to any motor, they shall be furnished, set in place and wired by TC contractor. Such devices shall be provided at low voltage unless technically impossible

3. Electrical contractor is responsible for wiring from disconnect to starter and from starter to motor, unless factory wired.
 4. Temperature control contractor shall provide conduit and wire from auxiliary contact in motor starter to the detector so that the unit shuts down in all operating modes. Fire Alarm Contractor to wire from detector to fire alarm panel.
 5. Each division shall be fully responsible for any control panels as called for on the drawings or specifications.
 - a. Electrical Contractor shall provide all power and control wiring to fire/smoke or smoke dampers. HVAC, Controls, Electrical, and Fire Alarm Contractors shall provide parallel control wiring (with fire alarm having priority signal) to dampers and equipment utilized in both normal and smoke control modes, unless otherwise indicated.
 - b. Fire alarm system shall override automated building control system during smoke exhaust mode.
 - c. TC shall provide additional required wiring and controls when damper also serves a temperature control or zoning function.
- B. Power Wiring by Divisions 21, 22, and 23: The electrical power for certain equipment provided under Divisions 21, 22, and 23 may not be specifically indicated on the electrical drawings and must be provided by and field coordinated by the Divisions 21, or 23 trade requiring such power.

Sufficient power for this purpose shall be furnished as "spare" dedicated circuit capacity in Division 26's panelboards. All wiring, conduit and electrical devices downstream of the panelboards is the responsibility of the Divisions 21, and 23 trade requiring the power.

1. Such equipment is hereby defined as:
 - a. Electrical heat trace. Required heat trace locations, capacities and specification are shown on the plumbing drawings.
 - b. Infrared plumbing fixtures. Fixtures requiring power are shown on the plumbing drawings and schedules. Provide junction box and or receptacle as required by manufacturer.
 - c. Temperature control panels, control air compressors and line voltage power for 24v control transformers. Required connections are included in HVAC scope and will be shown by that contractor's control submittal drawings.
 - d. Motorized dampers and VAV boxes. Required locations and specification are shown on the mechanical drawings and HVAC specifications. HVAC contractor shall provide damper, controls and power.

1.5 GENERAL REQUIREMENTS

A. Connections:

1. Connections to all controls directly attached to ducts, piping and mechanical equipment shall be made with flexible connections.

B. Starters:

1. Provide magnetic starters for all three phase motors and equipment complete with:
 - a. Control transformers.
 - b. 120V holding coils.
 - c. Integral hand-off-auto switch.
 - d. Auxiliary contacts required for system operation plus one (1) spare.
 - e. Refer to Motors, Starters and Drives, requirements for additional information.

C. Remote Switches and Pushbutton Stations:

1. Provide remote switches and/or pushbutton stations required for manually operated equipment (if no automatic controls have been provided) complete with pilot lights of an approved type lighted by current from load side of starter.

D. Special Requirements:

1. Motors, starters and other electrical equipment installed in moist areas or areas of special conditions, such as explosion proof, shall be designed and approved for installation in such areas with appropriate enclosure.

E. Identification:

1. Provide identification of purpose for each switch and/or pushbutton station furnished. Identification may be either engraved plastic sign permanently mounted to wall below switch, or stamping on switch cover proper. All such identification signs and/or switch covers in finished areas shall match other hardware in the immediate area.

F. Control Voltage:

1. Maximum allowable control voltage 120V. Fully protect control circuit conductors in accordance with National Electrical Code.

G. DDC Control Interface

1. Fully coordinate the requirements of each division with regard to supplying a complete DDC Control System prior to submitting bid.
2. All control power shall be furnished via dedicated line voltage circuits.
3. Dedicated control circuits from electrical panelboards to DDC control panels and from electrical panelboards to dedicated DDC J-boxes (for distributed control components such as VAV boxes), and control transformer line voltage connections shall be provided by HVAC Contractor where required.
 - a. Exceptions: Where power wiring has been shown on Electrical Drawings.
4. Low voltage wiring from J-boxes to distributed control components, all low voltage connections, all control panels and all control transformers (not part of unitary equipment) shall be provided under Division 23.
3. Any additional power requirements shall be the responsibility of the Division 23 or Contractor requiring same, and provided at no additional cost to the City of New York.

1.6 CEILING AND CHASE CAVITY PRECEDENCE

- A. Coordinate ceiling cavity space carefully with all trades. In the event of conflict, install mechanical and electric systems within the cavity space allocation in the following order of precedence. A system with higher precedence may direct that systems of lower precedence be relocated from space, which is required for expedient routing of the precedent system.

1. Plumbing waste, cooling coil drain piping, and roof drain mains and leaders.
2. Steam and condensate piping.
3. Plumbing vent piping.
4. Supply, return and exhaust ductwork.
5. Electrical conduit greater than 3" diameter.
6. Hydronic branch and mains (greater than 2").
7. Domestic water piping.

- 8. Domestic hot and cold water branches.
 - 9. Electrical conduit branch feeders.
- B. Light fixtures have precedence in a zone, extending from the face of the ceiling to an elevation 2" above the height of the light fixtures.
 - C. Examine the contract documents of all trades (e.g. all Divisions 21, 22, 23, 26 and 28 the architectural floor plans, reflected ceiling plans, elevations and sections, structural plans and sections, etc.).
 - D. Coordinate necessary equipment, ductwork and piping locations so that the final installation is compatible with the materials and equipment of the other trades.
 - E. Prepare shop drawings for installation of all new work before installation to verify coordination of work between trades.
 - F. Provide access doors for all equipment, valves, clean-outs, actuators and controls which require access for adjustment or servicing and which are located in otherwise inaccessible locations.
 - 1. For equipment located in "accessible locations" such as lay-in ceilings: Locate equipment to provide adequate service clearance for normal maintenance without removing architectural, mechanical, electrical or structural elements such as the ceiling support system, electrical fixtures, etc. "Normal maintenance" includes, but is not limited to: filter changing; greasing of bearings; using p/t ports for pressure or temperature measurements; and replacement of ballasts, fuses, etc.
 - 2. All system components requiring access shall be grouped together to reduce the quantity of access doors required.
 - G. See "Basic Mechanical Materials and Methods" for additional access door requirements if section has been included in this specification.

PART 2 – PRODUCTS

2.1 MOTOR HORSEPOWER

- A. In general, all motors $\frac{3}{4}$ HP and above shall be three phase, all motors $\frac{1}{2}$ HP or less shall be single phase. Refer to electrical drawings and equipment schedules for more information.
- B. Voltage and phase of motors as scheduled on the electrical drawings shall take precedence in the case of a conflict between the mechanical and electrical drawings or general condition 2.1. A., above.
- C. Work under Divisions 21, 22 and 23 includes coordinating the electrical requirements of all mechanical equipment with the requirements of the work under Divisions 26, 27 and 28, before ordering the equipment.
 - 1. If motor horsepowers are changed under the work of Divisions 21, 22 or 23 without a change in duty of the motor's driven device, coordination of additional electrical work (if any) and additional payment for that work (if any) shall be provided under the section of Divisions 21, 22 or 23 initiating the change. Increases or decreases in motor horsepower from that specified shall not be made without written approval from the Commissioner.

PART 3 - EXECUTION - (Not Used)

END OF SECTION

SECTION 23 05 03**BASIC MECHANICAL MATERIALS AND METHODS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. This Section supplements General Conditions.
- B. Where contradictions occur between this Section and General Conditions, the most stringent of the two shall apply. The design team shall decide which is most stringent.
- C. Provisions of this Section shall also apply to all Sections of Divisions 21, 22 and 23.

1.2 SUBMITTALS

- A. Manufacturer's Data - Submit manufacturer's data for:
 - 1. Access panels.
 - 2. Fire stopping materials.
 - 3. Heat Trace.
- B. Application Data - Submit application data for firestopping materials showing UL required installation details for every combination of pipe material, penetrated structure, opening size and required fire rating within the scope of this project. Application data drawings shall include UL system number.

PART 2 – PRODUCTS**2.1 ACCESS PANELS**

- A. See Architectural specification for access panel types and finishes.
 - 1. If panels are not specified in architectural specification, comply with the following:
 - a. Manufacturers:
 - 1) Design Basis: Milcor Division, Inryco, Inc.
 - 2) Other Acceptable Manufacturers:
 - a) Birmingham Ornamental Iron Co.
 - b) Karp Associates, Inc.
 - c) Wilkenson Co., Inc.
- B. Construction:
 - 1. Doors: 14 gauge steel.
 - 2. Frames: 16 gauge steel.
 - 3. Fire Rating: Equivalent to construction in which installed.
 - 4. Latches: Flush or concealed, ¼ turn.
 - 5. Finish: Selected by Architect.

2.2 FIRE STOPPING MATERIAL

A. Manufacturers:

1. Design Basis: 3M.
2. Other acceptable manufacturers:
 - a. GE
 - b. Metalines
 - c. Hilti

B. General Requirements:

1. Products to be used shall have been tested in accordance with ASTM E 814-88, and be listed in the UL Fire Resistance Directory.

C. Bare Piping:

1. Model: FD 150, or CP-25.

D. Insulated Piping:

1. Model: CP-25 or FS-195, Intumescent.
2. "No-sag" or "self-leveling" as required.

E. Accessories:

1. Provide fasteners, restricting collars, backing materials, and protective coatings as required to comply with the UL system listing.

2.3 HEAT TRACE

A. Manufacturers:

1. Design Basis: Raychem.
 - a. Model: XL-Trace for freeze protection applied between pipe and insulation.
 - b. Model: Ice stop for freeze protection applied inside storm drain leaders and down spouts.
2. Other acceptable manufacturers:
 - a. Thermon
 - b. Hevi-Duty/Nelson

B. Features:

1. Self regulating at all points along its length.
2. 90% power reduction from 40°F pipe temperature to 150° pipe temperature.
3. No overheating if crossed.
4. Provide outer jacket and braided copper shield for use inside roof drain leaders or on piping without a ground path.
5. UL listed and approved for use in New York City.

C. Accessories:

1. Provide tee, splice, and end seal kits as required by the manufacturer.

2. Provide ambient sensing thermostat in a NEMA 4x enclosure, with three (3) contacts rated at 22 amps each.

2.4 SPARE PARTS

- A. Chilled water, condenser water, condensate return pumps and hot water pumps - For each pump listed, unless otherwise specified.

1. One set of wearing rings or seals.
2. One set of bearings.
3. One set of packing glands complete with rings, nuts and bolts.
4. Three gaskets for casing joint.
5. Sufficient stuffing box packing for four packings.

Where pump specifications do not require mechanical seals, packing glands or stuffing boxes, spares listed may be omitted. Spare set of seals shall be provided.

- B. Filters

1. The Contractor shall furnish a minimum of 2 complete spare filter sets for the filters for all units.

- C. Miscellaneous Spare Parts

1. Water column glasses shall be provided for each tank utilizing one.
2. One complete set of gaskets shall be provided for each of the following pieces of equipment:
 - a. All manhole and handhole openings for the expansion of tank and blow down tank.
 - b. Converts (oil and hot water).
3. Furnish one complete set of V-belts for each belt driven unit installed.

2.5 ESCUTCHEONS

- A. Provide escutcheons on pipes wherever they pass through ceilings, walls, floors, or partitions.
- B. Escutcheons or pipes passing through outside walls shall be Ritter Pattern and Casting Co., No. 1, solid, cast brass, flat type secured to pipe with set screw.
- C. Escutcheons for pipes passing through floors shall be Ritter Pattern and Casting Co., No. 36A, split-hinged, cast brass type, designed to fit pipe on one end and cover sleeve projecting through floor on the other end.
- D. Escutcheons for pipes passing through interior walls, partitions, and ceilings shall be Ritter Pattern and Casting Co., No. 3A, split-hinged, cast beams chromium plated type.

PART 3 – EXECUTION**3.1 CUTTING AND PATCHING**

- A. Refer to Architectural sections of the Specifications for additional requirements.
- B. Provide measurements, drawings and layouts to installers of other work so that required openings may be provided as construction progresses. Any cutting and patching made necessary by failure to provide this information shall be done at no increase in the contract amount.
- C. All cutting and patching of existing work required for Plumbing and HVAC work is included in the scope of the plumbing and HVAC contracts. Finish patching, painting and restoration of finishes outside of primary work area is the Plumbing and HVAC contractor performing work. Finish patching, painting and restoration of finishes in primary work area is by others. Rough patching, finish patching, painting and/or restoration of finishes outside of the primary work area is by each trade contractor.
- D. Where possible, mark openings to be cut on existing construction. Otherwise, provide measurements, drawings and layouts to the trade doing the cutting so that openings may be provided as construction progresses.
- E. Cutting Concrete:
 - 1. Where authorized, cut openings through concrete for pipe penetration and similar services by core drilling or sawing.
 - 2. Do not cut by hammer-driven chisel or drill.
- F. Cutting:
 - 1. Cut openings in accordance with layouts, measurements or drawings of the Installer of work requiring openings. Cut openings in concrete by core drilling or sawing; not by hammer-driven chisel or drill.
 - 2. Coordinate the location of all openings with structural drawings. Report any discrepancies to Commisioner. Do not proceed with work until discrepancies have been resolved.
 - 3. Do not endanger or damage other work through the procedures and processes of cutting to accommodate mechanical work.
 - 4. Review the proposed cutting with the Installer of the work to be cut, and comply with his recommendations to minimize damage.
 - 5. Where necessary, engage the original Installer or other specialists to execute the cutting in the recommended manner.
- G. Patching:
 - 1. Where patching is required to restore other work because of either cutting or other damage inflicted during the installation of mechanical work, engage experienced craftsmen to complete the patching of the other work.
 - 2. Restore the other work in every respect, including the elimination of visual defects in exposed finishes.
 - 3. All openings in fire rated construction shall be patched and sealed with U.L. approved sealant to maintain the fire integrity of the structure.

H. Perform cutting, patching and restoration of finishes required to:

1. Uncover work to provide installation of ill-timed work.
2. Remove and replace defective work.
3. Remove and replace work not conforming to requirements of the Contract Documents.
4. Remove samples of installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from the Commissioner, uncover and restore work to provide for Commissioner's observation of concealed work.

I. Painting:

Paint all surfaces marred by cutting and/or patching to match existing.

1. Engage experienced painters.
2. Comply with requirements of Painting Sections of the Specification.

J. Structural Limitations:

1. Do not cut or drill into structural framing, walls, floors, decks, and other members intended to withstand stress, except with Engineer's written authorization.
 - a. Provide lintels, columns, braces and other temporary and permanent supports made by cutting.
 - b. Submit shop drawings of permanent supports.
 - c. Do not penetrate legs of structural "T's" or any other location where pre-stressed structural chords are likely to be encountered when cutting or drilling.

K. Provide inspection via metal detector or x-ray to identify existing concealed utilities when existing conditions make it apparent that concealed utilities may exist.

3.2 ACCESS PANELS

A. Furnish access panels where indicated and at locations where required for access to:

1. Concealed valves
2. Dampers
3. Control devices
4. Equipment servicing
5. Shock arresters
6. Air vents
7. Flow measuring and balancing stations
8. Any other device or item equipment requiring maintenance, adjustment or service.

B. Deliver access panels for installation by the trade responsible for surface in which installed.

1. Provide instructions for location.
2. The minimum size for access doors shall be the larger of 24"x24" or to fit the size of equipment to be removed.
3. If calculation of required access doors under paragraph A of this section identifies less than 1 access door per 200 square feet of ceiling and wall construction, the quantity of access doors shall be increased to 1 per 200 square feet of ceiling and wall construction.

- C. See "mechanical and electrical coordination" for additional access door requirements if section has been included in this specification.

3.3 SLEEVES

- A. Provide sleeves for piping passing through walls, floors and roofs.
- B. Set pipe sleeves and inserts in place before concrete is poured. Coordinate the placing of these items to avoid delaying concrete placing operations.
- C. Locate chases, shafts, and openings required for the installation of the mechanical work during framing of the structure. Do any additional cutting and boring required due to improperly located or omitted openings without cost to the City of New York under the supervision of the Commissioner.
- D. Size sleeves for below grade pipe a minimum of 2" beyond outside of pipe.
- E. Coat surface of all sleeves in contact with concrete, masonry or soil with two coats of coal tar bitumastic paint.
- F. Provide Sleeves as Follows:

<u>Sleeve Location</u>	<u>Sleeve Material</u>
Interior Stud Partition Walls	Adjustable galvanized sheet metal with wall flanges and plaster lip, 2" and smaller – 22 gauge, 3" through 6" – 20 gauge, 8" and larger – 18 gauge.
Nonmembrane Floor, Construction	Non-adjustable galvanized sheet metal with deck flange and end cap, 2" and smaller – 22 gauge, 3" – 20 gauge, 4" and larger – 16 gauge.
Floors of Mechanical Rooms, Concrete Walls or Masonry Walls Above Grade.	Standard weight galvanized steel pipe.

- G. Length of Sleeves as Follows:

<u>Location</u>	<u>Sleeve Length</u>
Floors	Equal to depth of floor construction including finish. Extend minimum of 1" above finished floor level within partitions, mechanical rooms, pipe chases and finished areas.
Roofs	Equal to depth of roof construction including insulation. Extend to 2" above maximum flood depth where rooftop retention is provided.
Walls	Equal to depth of construction.

3.4 FIRE STOPPING

- A. Install firestopping materials in accordance with their UL and ASTM tested methods.
- B. Coordinate required annular space with size of pipe and sleeve.

C. Requirements for specific systems:

1. Cold piping - includes chilled water, domestic water, storm water and refrigerant: Insulation and vapor barrier shall be continued through wall and firestopping for "insulated piping" shall be provided.
2. Hot piping - to 250°F -includes domestic hot water, steam to 15 psig and heating hot water: The Contractor has the option of continuing the insulation through the penetration and providing firestopping for "insulated piping", or stopping the insulation on either side of the penetration and using firestopping for "uninsulated piping".
3. High temperature piping, over 250°F or over 15 psig steam: Contractor shall stop insulation and provide firestopping for high temperature piping.

3.5 HEAT TRACE

- A. Heat trace cable shall be installed by a licensed electrician. HVAC contractor shall subcontract this work to a licensed electrician if HVAC contractor is not a licensed electrician.
- B. Apply the heat trace cable on the pipe after pressure testing.
 1. Do not spiral wrap on pipe.
 2. Make one wrap at valves.
 3. Secure to pipe with methods approved by manufacturer.
- C. Apply "Electrically Traced" signs on outside of insulation.
- D. Test with a 1000 VDC meager minimum resistance 20 mega ohms.
- E. Heat trace shall be sized as follows, based on 0°F ambient, to maintain 40°F pipe temperature:

PIPE SIZE	1" INSULATION	2" INSULATION
Less than 2"	3 w/ft.	3 w/ft
2", 2½", 3"	5 w/ft	3 w/ft
4", 5", 6"	8 w/ft	5 w/ft
8", 10", 12"	(2 cable circuits) 8 w/ft ea.	8 w/ft

- F. Provide heat tracing on all pipes installed within the intake, relief and exhaust shafts.

3.6 EQUIPMENT BASES AND SUPPORTS

- A. Supporting Steel: Provide supporting steel not indicated on the Structural Drawings for equipment, pipe ductwork, and other pieces of this Division's work requiring same.
 1. Submit shop drawings and structural calculations to the Engineer for information and records.
 2. Brace and fasten with flanges bolted to structure.
 3. Paint supporting steel with one coat of primer paint in the shop after fabrication welding is complete. Paint completed field joints with one coat of matching primer.

B. Housekeeping Bases:

1. Concrete bases for pumps, boilers, tanks, fans, etc., including anchor bolts and inserts, will be provided in accordance with American Concrete Institute (ACI) and American Society for Testing and Materials (ASTM) Standards for housekeeping pads and equipment support bases.
2. The concrete shall be placed in accordance with setting diagrams and sizes furnished by the equipment installer.
3. The Section furnishing the equipment shall provide not less than 4" high concrete bases for all pumps, refrigeration machines, compressors, and rotating machinery. Bases shall extend six inches beyond machinery base in all directions, with top edge chamfered. Provide 1/2" x 6" steel dowels into floor to anchor bases. Provide anchor bolts set in pipe sleeves, two sizes larger than anchor bolts for securing machinery. After anchor bolts are aligned with equipment bases, fill sleeves with concrete and allow to set.

3.7 DRIP PANS**A. Drip Pans:**

Where possible to run mechanical piping elsewhere, do not run mechanical piping directly above electrical (or electronic) work which is sensitive to moisture. Otherwise, provide drip pans under mechanical piping, sufficient to protect electrical work from dripping.

1. Locate pan immediately below piping, and extend a minimum of 6" on each side of piping and lengthwise 18" beyond equipment being protected.
2. Fabricate pans 2" deep of reinforced galvanized or aluminum sheet metal with rolled edges and soldered or welded seams; 22 gauge galvanized steel.
3. Provide 3/4" copper drainage piping from pan to nearest floor drain or similar suitable point of discharge, and terminate pipe as an open-sight drainage connection.
4. Provide permanent support and anchorage to prevent displacement of drip pans.
5. Insulate bottom of pan where pan is subject to the frequent discharge of water or materials less than 60°F.

END OF SECTION

SECTION 23 05 13**MOTORS AND STARTERS****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Submit manufacturer's product data.
 - 1. Motors: Identify by unit served. Include:
 - a. Voltage
 - b. Phase
 - c. Horsepower
 - d. Frame
 - e. Insulating class
 - f. Efficiency
 - g. Power factor
 - h. Index number
 - i. Speed
 - j. Starting characteristics
 - 2. Starters: Identify by motor served. Include:
 - a. Enclosure, NEMA Type
 - b. NEMA size
 - c. Accessories, switches, transformers, etc.
 - d. Wiring diagram
 - e. Auxiliary contacts
 - f. Thermal overload size
 - 3. Submit as part of packaged unit submittals when purchased as part of item of equipment.

1.2 SINGLE MANUFACTURER

- A. Provide all motors, except those factory mounted, by a single manufacturer.
- B. Provide all starters, except those factory mounted, by a single manufacturer.
- C. "Factory mounted" means "as part of a packaged unit" where the motor is not purchased separately from the driven equipment.

PART 2 - PRODUCTS**2.1 MOTORS (OTHER THAN FACTORY MOUNTED)**

- A. Manufacturers:
 - 1. Design Basis: Reliable
 - 2. Other Acceptable Manufacturers:
 - a. General Electric
 - b. Westinghouse
 - c. U.S. Motor
 - 3. Factory mounted motors may be by equipment manufacturer's standard supplier.
- B. Bearings: Ball bearings, grease lubricated with grease fittings.

- C. Enclosure: As required by location.
- D. Service Factor: 1.15.
- E. Full-Load Operation: At 105°F and altitude of project.
- F. Overload Protection:
 - 1. Type: Trip-free thermal overload relay.
 - 2. Location: Each ungrounded conductor.
 - 3. Reset: Manual.
 - 4. Ambient Temperature Compensation: Provide where required.
 - 5. Overload protection to be sized for nameplate running amps.
- G. Insulation:
 - 1. Constant Speed: Class B.
 - 2. Variable Frequency Controlled: Class F.
- H. Efficiency Ratings:
 - 1. All motors one horsepower and larger, except as noted, shall be premium efficiency motors, in accordance with NEMA Standard MG1-2003, Tables 12-12 and 12-13.
- I. Electrical Characteristics:
 - 1. Refer to sections 23 05 01, Mechanical and Electrical Coordination.
 - 2. Motors ½ hp and smaller shall be 115-volt single phase.
 - 3. Motors ¾ hp and larger shall be three phase, of voltage shown in Electrical Section of Contract Documents.
- J. Multi-speed Motors:
 - 1. Type: Motors may be one of the following:
 - a. Two speed, two winding 1800/900 rpm.
 - b. Two speed, one winding 1800/900 rpm.
- K. Variable Speed Drives:
 - 1. All motors operated by a variable speed drive shall be rated for inverter duty.
 - 2. Motor insulation shall be rated for 1200-volt peak.
 - 3. Refer to VFD specification for additional requirements if included in this specification.

2.2 MOTORS (FACTORY MOUNTED)

- A. Provide premium efficiency motors.
- B. Variable Speed Drives:
 - 1. All motors operated by a variable speed drive shall be rated for inverter duty.
 - 2. Motor insulation shall be rated for 1200 volt peak.
 - 3. Refer to VFD specification for additional requirements if included in this specification.

2.3 STARTERS

A. Manufacturers:

1. Allen Bradley
2. Cutler-Hammer
3. General Electric
4. Square D

B. General:

1. Starters shall be standard NEMA sizes and UL listed.

C. Type: Across the line except where noted.

D. Enclosure: NEMA Type as required for location. Provide stainless steel enclosures in wash down areas, kitchens, dishwasher areas and any other areas where equipment will be exposed to moisture.

E. Overload Protection:

1. Type: Trip-free thermal overload relay for each ungrounded conductor.
2. Reset: Manual.
3. Ambient Temperature Compensation: Provide where required.
4. Overload protection to be sized for nameplate running amps.

F. Auxiliary Contacts:

1. Number: Provide three per starter as required for control sequence, and one (1) auxiliary contact.
2. Switchable type, easily changed from N.O. to N.C. without removing from its mounting.

G. Switches in Cover:

1. Manually Controlled: Three wire start-stop.
2. Automatically Controlled: Hand-off-automatic.
3. Start and stop indicating lights.
4. Equipment used for life safety (smoke exhaust, etc.): Hand-Automatic.
5. Equipment not designed to run continuously: Off-Automatic.

H. Control Transformer:

1. Provide when line voltage exceeds 208 volts.
2. Secondary wiring shall have one leg fused and the other grounded.
3. Secondary voltage not to exceed 120 volts.

I. Provide starters for all motors as follows:

1. Single phase motors less than ½ hp.
 - a. With internal overload protection: None.
 - b. Without internal overload protection:
 - 1) Manually Controlled: Manual starter.
 - 2) Automatically Controlled: Magnetic starter.
2. Single phase motors ½ hp and larger:

- a. Manually Controlled: Manual starter.
 - b. Automatically Controlled: Magnetic starter.
- 3. Three Phase Motors: Magnetic starter.
- J. Soft Start Starters:
 - 1. Provide Y-Delta or solid state reduced voltage starters for all motors 50hp and larger.
 - 2. Starter shall limit starting voltage to 200% of full load voltage.
- K. Multi-Speed Starters:
 - 1. Starters shall be suitable for the type multi-speed motor selected.
 - 2. Provide time delay for automatic transfer from high to low speed.
- L. Housing coils to be 120V.
- M. Motor Protection: (above 20 hp)
 - 1. Provide Single-phase protection.
 - 2. Provide under-voltage protection.
- N. Disconnecting Means
 - 1. Provide combination starters-disconnects for all starters unless specifically stated otherwise.

PART 3 - EXECUTION

3.1 MOTORS

- A. Install motors on motor mounting systems so coupling or belt drive is properly aligned. Provide proper belt tension. Dowel direct coupled motors.

3.2 STARTERS

- A. Deliver to installer of electrical work.
- B. All safety devices shall be wired so that they will stop the motor with a hand-off-automatic switch in the hand as well as the automatic position.

END OF SECTION

SECTION 23 05 23**VALVES****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Manufacturer's Data: Submit manufacturer's product data including:
 - 1. Dimensions
 - 2. Sizes
 - 3. End Connections
 - 4. Weights
 - 5. Installation instructions
 - 6. Instructions on repacking and repairing valves.
 - 7. Range of flow for balancing valves and plug valves.
- B. Valve Tag List: See requirements in this Specification.

PART 2 - PRODUCTS**2.1 GENERAL**

- A. Where type or body material is not indicated, provide valve with pressure class selected from MSS or ANSI standards, based on the maximum pressure and temperature in the piping system.
- B. Except for balancing or otherwise indicated, provide valve of same size as connecting pipe size.
- C. Unless specifically required by note or symbol, all water valves shall be ball or butterfly valves. If ball, butterfly, globe, plug, or balancing valves are called out by note or symbol, only that type of valve is acceptable.
- D. Ball valves or butterfly valves may be used in lieu of gate valves in non-balancing applications when pressure and temperature ratings are adequate.
- E. Where pipe sizes overlap, contractor has the option of threaded or flanged valves.
- F. Where grooved pipe mechanical coupling systems are accepted, provide flange adapters to mate with valves as specified below. Valves manufactured by the mechanical coupling system manufacturer shall not be used unless they meet all of the specified requirements for a given valve.
- G. All valves shall be domestically manufactured unless approved for use by Engineer.
- H. All components in hydronic systems shall be compatible with propylene glycol and water solution.
- I. All valves shall be of a design which the manufacturer lists for the service and shall be of materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless a higher grade or quality is herein specified.

2.2 GLOBE AND ANGLE VALVES

- A. Manufacturers:
 - 1. Other Acceptable Manufacturers:
 - a. Crane
 - b. Nibco
 - c. Powell
 - d. Victaulic (for Grooved Pipe Systems)
 - e. Gruvlok
 - f. Stockham
 - g. Jenkins
 - h. Walworth
- B. Size 2" and Smaller: Milwaukee Model 591A. Bronze, 150 SWP at 406 deg. F., 300 WOG at 150 deg. F., Non-Shock, Heavy Duty Service, Special Hardened Stainless Steel Seat Ring and Disc, Union Bonnet, Gland Packed, Threaded Ends.
- C. Size 2" and Smaller, Globe (Steam): Crane Model No. 382P. Bronze, 300 lb. WSP, Threaded.
- D. Size 2" and Smaller, Angle (Water & Gas): Milwaukee Model 595T. Bronze Body, 150 WSP, 300 WOG, Threaded, Union Bonnet, Angle Bronze Disc.
- E. Size 2½" and Larger, Globe: Milwaukee Model F-2981. Iron, 125 SWP, 200 WOG, Non-Shock, Solid Disc, Bolted Bonnet, Gland Packed, Flanged Ends.
- F. Size 2 ½" and Larger, Angle (Steam): Crane Model 21E. Iron body, 250 lb. WSP, OS&Y, Flanged ends - Bronze Trim.
- G. Except where otherwise noted, all valves for use with copper tubing shall be as follows:
 - 1. Globe valve: 2" & smaller: Jenkins No. 1310, 125 lb. WSP, Bronze. 3" and smaller: 300 lb. Nonshock CW bronze with solder joint adapter.
 - 2. Angle valve: 2" and smaller: Jenkins No. 1311, 125 lb. WSP, bronze. 3" and smaller: Walworth No. 1202, 300 lb. Nonshock CW bronze with solder joint adapter.
- H. All refrigerant valves shall be silver brazed joint as follows:
 - 1. Globe Valves – 1-1/8" O.D. and smaller: packless, Henry type 626; 1-3/8" O.D. and larger: packed, wing cap, Henry type 203.
 - 2. Angle Valves – 1-1/8" O.D. and smaller: packless, Henry type 647 and 642; 1-3/8" O.D. and larger: packed, wing cap, Henry type 216.

2.3 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Design Basis: Milwaukee
 - 2. Other Acceptable Manufacturers:
 - a. Crane
 - b. Nibco
 - c. Powell
 - d. Stockham
 - e. Victaulic (for Grooved Pipe Systems)
 - f. Gruvlok

- g. Jenkins
 - h. Walworth
- B. Size 2" and Smaller: Bronze, 200 psi SWP, 400 psi WOG, 5° straight through pattern, bronze disc, stainless steel seat, MSS-SP 80, Type 3.
- 1. Model: 518
- C. Size 2½" and larger: Crane No. 373, 125 lb. WSP, bronze trimmed, iron body.
- D. All refrigerant valves shall be silver brazed joint as follows:
- 1. Check Valves – 7/8" O.D. and smaller: brass, Henry type 116A; 1-1/8" O.D. and larger: bronze, Henry type 205.

2.4 SILENT/WAFER CHECK VALVES

- A. Manufacturers:
- 1. Design Basis: Metra Flex
 - 2. Other Acceptable Manufacturers:
 - a. Cla-Val
 - b. GA Industries
 - c. Nibco
 - d. Tyco
 - e. Victaulic (for Grooved Pipe Systems)
 - f. Gruvlok
 - g. Stockham
- B. Size 2" and Smaller: MetraFlex Model CVO. Cast Iron body, Bronze trim, Center guided single disc, 200 PSI rating.
- C. Pipe size 2 ½" to 6": MetraFlex Model CVO. Cast Iron body, Bronze trim, Center guided single disc, 200 PSI rating.
- D. Where application or building height causes working pressure to exceed 150 psi, provide silent check valves 3" & up: Williams-Hager Fig. 329, 250 lb. WSP, semi-steel.

2.5 GATE VALVES

- A. Manufacturers:
- 1. Design Basis: Milwaukee
 - 2. Other Acceptable Manufacturers:
 - a. Crane
 - b. Nibco
 - c. Stockham
 - d. Victaulic (for Grooved Pipe Systems)
 - e. Gruvlok
 - f. Jenkins
 - g. Walworth
- B. Size 2" and Smaller (Water & Gas): Milwaukee Model 1174. Bronze Gate Valve, 400 PSI WOG Non-Shock, Heavy Duty Service, Solid Wedge Disc, Rising Stem, Stainless Seat, Union Bonnet, Threaded Ends.

- C. Size 2" and Smaller (Steam): Milwaukee Model 1174. Bronze Gate Valve, 400 PSI WOG Non-Shock, Heavy Duty Service, Solid Wedge Disc, Rising Stem, Stainless Seat, Union Bonnet, Threaded Ends.
- D. Size 2½" and Larger (Water & Gas): Milwaukee Model F-2885. 3% Nickel Iron Body, 125 PSI Fluid Pressure to 450 deg. F or 232 deg. C. 200 PSI Non-Shock Cold Water, Oil or Gas. -200 deg. F. to 150 deg. F, or -29 deg. C to 66 deg. C, Stainless Steel Trim, OS & Y, Bolted Bonnet, Solid Wedge, Flanged Ends.
- E. Size 2½" and Larger (Steam): Milwaukee Model F-2885. 3% Nickel Iron Body, 125 PSI Fluid Pressure to 450 deg. F, Stainless Steel Trim, OS & Y, Bolted Bonnet, Solid Wedge, Flanged Ends.
- F. Except where otherwise noted, all valves 2" and smaller for use with copper tubing shall be Crane No. 634E, 300 lb. WSP, rising stem.
- G. Gate valves shall not be used for refrigerant systems.

2.6 BALL VALVES

- A. Manufacturers:
 - 1. Design Basis: Nibco\
 - 2. Other Acceptable Manufacturers:
 - a. Apollo
 - b. Dyna Quip
 - c. Hammond
 - d. Milwaukee
 - e. Victaulic (for Grooved Pipe Systems)
 - f. Watts
 - g. Bray
 - h. Gruvlok
 - i. Stockham
- B. Cast bronze, 150, SWP, 600 WOG (min), chrome plated solid, tunneled bronze ball (stainless for steam service), two piece design, blow-out proof stem, adjustable packing gland nut (allowing handle to be removed without leaking) TFE seats, MSS-SP-110.
 - 1. Model: T-585-70 - full.port.
- C. Options: Provide the following where required:
 - 1. Extended stems for insulated valves.
 - 2. Memory stop device for balancing applications.
 - 3. Tee handle for tighter areas.
 - 4. Hose end and cap for drain.
 - 5. Mounting pads for actuator.
 - 6. Provide "stop and drain" for compressed air.
 - 7. Ball Valves up to 2" may be used for all water services, other than radiation balancing, as an alternate to gate valves, globe valves and balancing cocks.
 - 8. Ball valves shall be bronze body, bronze ball and stem, Teflon seats and seals threaded ends, 400 psig cold W.O.G. Worchester No. 411T-SE or equal.

2.7 BALANCING VALVES

- A. Manufacturer, variable orifice type:
 - 1. Armstrong
 - 2. Tour and Anderson
 - 3. Nibco
- B. Manufacturers, valve and venturi type:
 - 1. Flowset
 - 2. Gerand
 - 3. Griswold
 - 4. HCI
 - 5. Nexus
 - 6. Preso
- C. Valves shall be rated 175 psi at 250°F.
- D. Connections: Threaded or flanged.
- E. Pressure Reading Ports:
 - 1. "P/T" Ports, Shraeder valves, or Hansen type quick connect. No "refrigeration" fittings.
- F. Design, variable orifice type:
 - 1. Globe-type valve.
 - 2. Multiple turns of handwheel from full closed to full open.
 - 3. Bubble-tight shut-off.
 - 4. Taps upstream and downstream.\
 - 5. Memory stop device to allow valve to be returned to balanced position after being closed.
- G. Design, valve and venturi type:
 - 1. Ball valve complying with the above requirements for ball valves.
 - 2. Fixed orifice or venturi, upstream of valve.
 - 3. Taps on venturi, upstream and downstream.
 - 4. Memory stop device to allow valve to be returned to balanced position after being closed.
 - 5. Regardless of the manufacturer's claims, these valves shall not be considered as tight shut off for service. Provide additional valves for equipment isolation.
- H. Insulation: Provide premolded insulation conforming to the valve body. Material shall have a flame spread of 25 and a smoke development of 50.
- I. Balancing Cocks: Up to 2"
 - 1. Bronze.
 - 2. Screwed 120 psi WSP Class; similar to Fig. 554.
 - 3. 250 psi WSP Class; similar to Fig. 576.

2.8 DRAIN VALVES

- A. Gate or ball valve with hose end adapter and cap. Crane 117 or approved equal.

- B. Drain valves: 2" and smaller: Crane No. 451, 200 lb. WOG, non-rising stem, Hose end, bronze with bronze cap and chain.

PART 3 - EXECUTION

3.1 GENERAL

- A. Comply with the following requirements:

1. Install valves except butterfly with stems pointing up, and as close to vertical as possible. Butterfly valves to be offset at least 10° from vertical.
2. Install valves at each piece of equipment, fixture or appliance so that the supply and return services can be shut off to remove the item without draining the remainder of the piping system.
3. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves so as to be accessible.
4. Combination balancing and shut-off valves may be used instead of a separate balancing valve and shut-off valve if the valve has a memory stop and the manufacturer lists its use as a leak-proof service valve.
5. Provide drain valves at main shut-off valves, low points of piping and apparatus.
6. Provide separate support where necessary.
7. Do not allow meter connections of balancing valves to point downward.
8. Install valves so bypass valves are accessible.
9. Furnish all valves as indicated on the plans, or as may be required for the proper control of the pipe lines installed under this Specification, so that any fixture, line or piece of apparatus may be cut out for repair without interference or interruption of the service to the rest of the Building. All water valves shall have a minimum working pressure of 125 psi, water rated unless otherwise noted on the Drawings or specified herein. All valves shall be of one manufacture.
10. All gate valves within the building shall be wedge gate valves with painted iron wheel handles, shall have gland followers in stuffing boxes, and shall be constructed that they may be repacked while open and under pressure. All valves shall have the name of the manufacturer and working pressure cast or stamped thereon.
11. All gate valves 3" and smaller shall be all bronze with brazed or screwed joint ends as required by the piping system in which they are installed.
12. Globe valves shall be of all bronze with composition disc, threaded or brazed joint ends as required by piping system in which they are installed.
13. Check valves up to and including 3" shall be all bronze swing check type with threaded or brazed joint ends.
14. Drain valves shall be 3/4" heavy cast brass with composition washers with male thread for hose connections.
15. Provide at the high point of hot water piping system a 1/2" automatic IBBM air relief valve, 125 PSI, WOG Class. Pipe drain to spill over adjacent floor drain or service sink.
16. All valves shall have the trademark of the manufacturer and the guaranteed working pressure cast or stamped on the body of the valve. All gates or globes, etc., shall be of one manufacturer and working pressure cast or stamped thereon.
17. The exterior valves shall conform to all applicable requirements of American Water Works Association C500-61 Standard for Gate Valves for Fire Water Work Service.
18. Install check and globe valves on downstream side of the shutoff valve on hot water circulating riser and branch lines.

19. Valves, where exposed and used in connection with finished piping, shall be same finish as the pipe.
 20. Provide shut-off valves and check valves on each pump discharge line.
 21. All valves used on branch piping to bathroom and kitchens shall be all bronze type globe valves with discs suitable for service to which they are connected.
 22. Install valves where required for proper operation of piping and equipment including valves in branch lines necessary to isolate sections of piping. Locate valves so as to be accessible.
 23. Install valves with bodies of metal other than cast iron where thermal or mechanical shock is indicated or can be expected to occur.
 24. Do not install bronze valves and valve components in direct contact with steel, unless bronze and steel are separated by dielectric insulator. Install bronze valves where corrosion is indicated or can be expected to occur.
 25. Select and install valves with outside screw and yoke stems, except provide inside screw non-rising stem valves where headroom prevents full opening of OS&Y valves.
 26. Except as otherwise indicated, install gate, ball, globe, and butterfly valves to comply with ANSI B31.1. Where throttling is indicated or recognized as principal reason for valve, install globe or butterfly valves.
 27. Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.
 28. Select and install valves with renewable seats, except where otherwise indicated.
- B. All valves of a given type shall be of one manufacturer.
- C. Provide extended stems on insulated system to prevent interference of operator with insulation.
- D. Provide chain wheel operators for valves more than 7' – 0" AFF in mechanical rooms and wherever shown on drawings.

3.2 CHECK VALVE INSTALLATION

- A. Swing and Check Valves:
1. Install only in horizontal lines unless absolutely impractical. If installed vertically, flow shall be upwards.
 2. Do not install in pump discharge piping.
- B. Silent Check Valves:
1. Install in all pump discharge lines.
 2. Silent check valves may be installed in vertical pipes with flow down upon Engineer's review for each instance.
- C. Installation of Check Valves:
1. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
 2. Horizontal Lift Check Valve: Install in horizontal piping line with stem vertically upward.
 3. Vertical Lift Check Valve: Install in vertical piping line with upward flow with stem vertically upward.
 4. Air Compressor Lift Check Valve: Install in air compressor discharge line.
 5. Spring Loaded Horizontal Lift Check Valve: Install in horizontal piping line with stem vertically upward.

D. Backflow Preventer:

1. Provide backflow preventer requirements as follows:
 - a. Vacuum breaker at all hose bibbs.
 - b. Reduced pressure on water entry.

3.3 VALVES USED FOR THROTTLING/BALANCING

- A. Balancing valves shall not be used for flow indication in pipes 2½" and larger, or in pump discharge piping.
- B. Throttling/Balancing Valves shall be selected so that the maximum design flow causes between 1' and 10' W.G. pressure drop or meter reading with the valve wide open.
- C. Install balancing valves used for flow indication with a minimum of five times the pipe diameter downstream and two times the pipe diameter upstream of a fitting or valve.
- D. Globe, ball, butterfly, or plug valves may be used for throttling/balancing. Provide an infinitely variable, lockable memory stop device to allow the valve to be returned to the "balanced" position after closing, and to prevent movement of the disc or plug during operation. When ball valves are used for throttling, provide an additional valve for equipment isolation.

3.4 COMBINATION THROTTLING/CHECK VALVES

- A. Combination throttling/check valves may be used in lieu of separate throttling and check valves on pump discharge piping. However, they may not be used for flow measurement.

END OF SECTION

SECTION 23 05 29**PIPE SUPPORTS AND ANCHORS****PART 1 - GENERAL****1.1 STANDARDS**

- A. Comply with MSS Standard Practice SP-58, SP-69 and SP-89, published by Manufacturer's Standardization Society of the Valve and Fitting Industry for type and size.

1.2 SUBMITTALS

- A. Submit manufacturer's product data on the following:
 - 1. Hangers other than clevis type.
 - 2. Anchors.
- B. Submit structural calculations for trapeze type supports.

PART 2 – PRODUCTS**2.1 PIPE HANGERS**

- A. General:
 - 1. Use adjustable pipe hangers on suspended pipe. Trapeze hangers may be used at the Contractor's option. Contractor shall be responsible for sizing supports.
 - 2. Chain, wire or perforated strap hangers will not be permitted.
 - 3. Isolate hangers in contact with dissimilar materials with dielectric hanger liners. Tape is not acceptable.
 - 4. Provide supports between piping and building structure where necessary to prevent swaying.
- B. Hanger Rods:
 - 1. Exposed in public areas: Zinc electroplated steel.
 - 2. Concealed or in service areas: Black threaded steel.
 - 3. Outside, exposed to weather: Hot dipped galvanized.
- C. Spot Concrete Inserts: Steel case and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods and lugs for attaching to forms.
 - 1. Size inserts to match size of threaded hanger rods.
 - 2. Inserts to be UL and FM listed.
 - 3. Minimum 1000 lb. Capacity with ½" rod.
- D. Channel Type Inserts:
 - 1. Standard channel support with anchor tabs on 4" centers, and nail holes for attaching to forms.
 - 2. Styrofoam inserts to prevent wet concrete seepage.
 - 3. Minimum 2000 pounds/foot capacity.

E. Expansion Anchors:

1. For use only in renovations or where modifications to piping layouts require installation away from pre-installed insert locations.
2. Inserts shall be of the drill, insert, expand type. Powder driven fasteners are not acceptable for piping.
3. Contractor shall select the appropriate type based on the following:

<u>Rod Size</u>	<u>Maximum Working Load</u>
3/8	600 pounds
1/2	1100 pounds
5/8	1800 pounds

F. Steel Structure Attachments:

1. Contractor may select welded or mechanically attached. All mechanically attached supports shall have jam nuts or other means to prevent loosening. Maximum loading requirements are as follows:

<u>Rod Size</u>	<u>Maximum Working Load</u>
3/8	600 pounds
1/2	1100 pounds
5/8	1800 pounds

G. Single Hangers:

1. Piping 2" and smaller: MSS type 1, Clevis hanger or type 7 adjustable swivel ring hanger. Minimum 180 pounds design load.
2. Piping 2" and smaller (steel): Clevis hanger, Grinnell Fig. No. 260, F & M Fig. No. 239, Paterson Fig. No. 100.
3. Piping 2" and smaller (copper): Adjustable wrought iron, Grinnell Fig. No. CT-65, F & M Fig. No. 364, Paterson Fig. No. 100 CT
4. Piping 2½" and larger: MSS type 1 Clevis hanger.
5. Piping 2½" to 4" (steel): Adjustable swivel pipe roll, Grinnell Fig. No. 174, F & M Fig. No. 2729, Paterson Fig. No., 16.
6. Piping 2½" to 4" (copper): Adjustable wrought ring, Grinnell Fig. No. CT-269.
7. Piping 5" and above: Two rod roller hanger, Grinnell Fig. No. 171, F & M Fig. No. 170, Paterson Fig. No., 142.
8. Bare copper pipe: Above hangers, plastic or Neoprene coating, sized for copper pipe O.D. and copper coated for identification.
9. Insulated pipe: Hangers to be sized for O.D. of insulation. Hangers shall not penetrate any insulation.
10. Cast iron pipe above hangers sized for O.D. of cast iron pipe.
11. Hanger wire, cable or perforated metal strapping are not acceptable.

H. Trapeze hangers and wall supports:

1. Channel strut or structural steel shapes. Contractor shall follow channel strut manufacturers guidelines for loading or provide structural steel supports designed by a professional Engineer, licensed in the state where the project is located.
2. All piping shall be attached to the support by means of a channel strut clamp, U-bolt, or pipe rollers which will maintain lateral position of the pipe but allow longitudinal movement. Provide dielectric isolation between all dissimilar metals.

3. All insulation shall be continuous at supports. Do not notch or penetrate insulation or vapor barrier.
 4. Kindorf or similar materials used for support of small piping shall not be used for piping 3" or larger.
 5. ½" through 3": Unistrut type channel and steel clamp.
 - a. Use Hydrosorb cushions on copper pipe.
 6. 4" and Over: Welded steel bracket and wrought steel clamp.
- I. Vertical Supports: Provide steel riser clamp at each floor penetration or every 14 foot supported from wall bracket. Do not anchor riser clamps.
- J. Hangers:
1. General: Adjustable wrought steel clevis with locking nut attachment.
 2. Multiple or Trapeze: Steel channels with welded spacers and hanger rods.
 3. Hanger Sizes and Spacing:
 - a. For drain piping, conform to the code requirements for spacing, and the following table for hanger rod sizes.
 - b. For steam and hydronic piping, conform to the following table:

PIPE TYPE	PIPE SIZE	MAXIMUM HORIZONTAL SPACING	MAXIMUM VERTICAL SPACING	MINIMUM HANGER ROD SIZE
Steel and Stainless Steel Pipe	½"	6'-0"	15'-0"	3/8"
	¾" thru 1¼"	8'-0"	15'-0"	3/8"
	1½" and 2"	10'-0"	15'-0"	3/8"
	2½" thru 3½"	12'-0"	15'-0"	½"
	4" and 5"	12'-0"	15'-0"	5/8"
Copper Pipe	½" thru 1"	8'-0"	10'-0"	3/8"
	1¼" thru 2"	10'-0"	10'-0"	3/8"
	2½" thru 3"	10'-0"	10'-0"	½"
	4"	10'-0"	10'-0"	5/8"
				¾"
Copper Tubing	1¼" and below	6'-0"	10'-0"	3/8"

* Submit routing and support plans to Commissioner for review.

- K. Insulated Pipe Supports:
1. Size pipe supports for outside diameter of pipe insulation.
 2. It is not acceptable to notch insulation or vapor barrier at supports.
- L. Pipes over five inches and over 120°F: Provide cast iron roller supports.

- M. Beam clamps - Hangers supported from floor steel shall be approved I beam clamps. I beam clamps for hangers supporting piping 2 inches and smaller shall be C & P Fig. No. 148 adjustable beam clamps. For piping 2-1/2 inches and larger, I beam clamps shall be wrought steel. C & P Fig. No. 268 or equal.
- N. Hangers for copper piping shall be copper plated.

2.2 INSULATION INSERTS

- A. Pipe shall be protected at the point of support by an insert of high density, foam glass insulation, encased in a sheet metal shield. Insert to be same thickness as adjoining pipe insulation. Insulation insert to extend one inch beyond sheet metal shield on all "cold" lines. If pipe hanger spacing exceeds ten feet and for all pipe roller applications, utilize double layer shield on bearing surface.
- B. Provide 180° insulation inserts when utilizing clevis hangers. Provide 360° insulation inserts at all trapeze and wall supports.

2.3 PIPE ANCHORS

- A. Manufacturers:
 - 1. Design Basis: Flexonics
 - 2. Other Acceptable Manufacturers:
 - a. Adsko
 - b. Keflex
 - c. Hilti
- B. Model AC with threaded ends and welded angle brackets for steel pipe.
- C. Model AC copper tube with solder ends and steel angle brackets brazed to tubing for copper tube.
- D. Anchors may be field fabricated similar to manufactured products specified.

2.4 PIPE GUIDES

- A. Manufacturers:
 - 1. Basis of Design: B-line.
 - 2. Other Acceptable Manufacturers:
 - a. Fee & Mason
 - b. Grinnel
 - c. M-Co
 - d. PHD
- B. Any of the Following:
 - 1. Spider Type: B3281-7.
 - 2. Roller Type: 2 sets of roller son opposite sides of pipe.
 - 3. Slide Type: B3893 with hold down lugs.
 - a. Not for use with cold piping.

4. Light duty, 1½" and smaller copper: U bolt or channel strut clamp (B2417) allowing clearance from O.D. of pipe or insulation.

2.5 ROOF MOUNTED PIPING

- A. Manufacturers:
 1. Miro Industries, Inc.
 2. Portable Pipe Hangers, Inc.
 3. Approved Equivalent.
- B. Description: Piping on roof shall be supported by an engineered prefabricated portable pipe system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of recycled rubber or plastic bases, hot dipped galvanized or stainless steel frame with threaded rods and suitable pipe hangers and supports. The system shall be custom designed to fit the piping and conduits to be installed and the actual conditions of service.
- C. Provide seismic restraints as required for seismic zone.

PART 3 – EXECUTION

3.1 INSTALLATION OF PIPE SUPPORTS

- A. Adequately support piping from the building structure with adjustable hangers to maintain uniform grading where required and to prevent sagging and pocketing.
 1. Provide supports between piping and building structure where necessary to prevent swaying.
 2. Do not support pipe from other pipe or equipment.
 3. Provide thrust restraints at all changes in direction on 8" and larger cast iron piping with no hub or hub and spigot fittings.
- B. Install hangers to provide minimum ½" clear space between finished covering and adjacent work.
 1. Place a hanger within one foot of each horizontal elbow.
 2. Space hangers generally as called for in Table in Part 2, Products.
- C. Use hangers, which are vertically adjustable 1-½" minimum after piping is erected.
- D. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.
 1. Set inserts in position in advance of concrete work.
 2. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
- E. Provisions for Movement: Install hangers and supports:
 1. To allow controlled movement of piping systems.
 2. To permit proper movement between pipe anchors.
 3. To facilitate the action of expansion joints, expansion loops, bends and offsets.
 4. To isolate force due to weight or expansion from equipment connections.

- F. In general, attach hangers to upper chord of roof trusses and floor joists, using long rods to facilitate pipe movement.
- G. Anchors:
 - 1. Use no pipe anchors. Arrange piping such that pipe expansion and contraction is accommodated by controlled movement of the pipe within the pipe supports. Provide sufficient offsets in branch piping to accommodate movement of main piping due to expansion and contraction.
- H. Where such heavy piping runs parallel with the floor beams properly designed auxiliary steel must be provided. The spacing of such auxiliary steel supports shall in no case be greater than the spacing of the floor beams running perpendicular to the corrugations of the permanent slab steel forms. The Contractor shall be responsible for designing such system.
- I. Assume the responsibility for the proper transfer of the loads to the piping systems to the structure. No additional cost to the City of New York should be expected for any corrective work during construction.
- J. Provide necessary structural members, hangers, and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations. In all cases where hangers, brackets, etc., are supported from metal decking and/or concrete construction, care shall be taken not to weaken decking and/or concrete or penetrate waterproofing. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot, or chilled, as required.
- K. Provide supplemental bolted steel in all locations where drilling of slab will create unacceptable noise in adjacent spaces.
- L. Where piping is run near the floor and not hung from the ceiling construction but is supported from the floor, such supports shall be of pipe standards with base flange and adjustable top yoke similar to C & P Fig. 247 or equal.
- M. All vertical piping shall be anchored by means of heavy steel clamps securely bolted or welded to the piping, and with end extension bearing on the building.
- N. Vertical runs of pipe not over 15 feet long shall be supported by hangers placed not over one foot from the elbows on the connecting horizontal runs.
- O. Vertical runs of pipe over 15 feet long but not over 60 feet long and not over 6 inches in size, or not over 30 feet long and not over 12 inches in size, shall be supported on heavy steel clamps. Clamps shall be bolted tightly around the pipes and shall reset securely on the building structure without blocking. Clamps shall be welded to the pipes or placed below couplings. Clamps shall be type 8, Federal Specification WW-H-171C, unless other types are approved.
- P. Piping in trenches shall hang from angle iron cross supports provided by the Contractor with two coatings of red lead primer and final coat of black asphaltum paint.
- Q. Hanger rods shall be attached to preset concrete inserts with steel reinforcing rod through the insert and both ends hooked over the reinforcing mesh. For pipes 4 inches and larger, rods shall extend through concrete slab above where they shall be attached to steel bearing plates 6" x 6" x 1/4".
- R. Piping shall not be hung from other piping, ducts, conduits or from equipment of other trades and no vertical expansion shields will be permitted. Hanger rods shall not pierce ducts.

- S. All water piping connected to rotating equipment within all mechanical spaces shall be isolated from the building structure by means of vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a steel spring in combination with a double deflection neoprene element within a rectangular steel housing. Combined static deflection shall be 1.375" minimum. Hangers shall have capability of supporting the piping at a fixed elevation during installation and shall incorporate an adjusting device to transfer the load to the spring. Deflection shall be indicated by means of scale. Vibration hangers shall be type PCDNHS made by Mason Industries.
- T. All steam condensate piping within all mechanical spaces shall be isolated from the building structure by means of double deflection neoprene vibration hangers inserted in the hanger rods. The vibration hangers shall consist of a double deflection neoprene element within a rectangular steel housing. Minimum static deflection shall be 1.375". Vibration hangers shall be type PCDNHS as made by Mason Industries.
- U. All piping running on walls shall be supported by means of hanger suspended from heavy angle iron wall brackets. No wall hooks will be permitted.

END OF SECTION

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SECTION 23 05 48
VIBRATION CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, and Specification Sections (General Requirements), apply to this Section.

1.2 DESCRIPTION

- A. Furnish and install all vibration control devices, accessories, materials, and related items. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.3 MATERIAL AND EQUIPMENT

- A. Design Basis: Mason Industries
- B. Alternate Manufacturers:
 - 1. Vibration Eliminator Co.
 - 2. Korfund Dynamics Corp.
 - 3. Amber/Booth Co.
 - 4. Vibration Mountings & Controls, Inc.
- C. Unless otherwise specified, supply only new equipment, parts and materials.

1.4 QUALITY ASSURANCE

- A. Firms regularly engaged in manufacture of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than ten (3) years.
- B. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.
- C. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.
- D. Supply and install any incidental materials needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim or additional payment.
- E. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

- F. Should any rotating equipment cause excessive noise or vibration, the Contractor 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 the unit in question.

1.5 SUBMITTALS

- A. Prior to ordering any products, submit shop drawings and the items listed below. The shop drawings must be complete when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal. Contractor shall provide:
1. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
 2. Detailed selection data for each vibration isolator supporting equipment, including:
 - a. The equipment identification mark;
 - b. A cut sheet of the isolated equipment showing equipment support points and operating weight at each point.
 - c. The isolator type;
 - d. The actual load;
 - e. The static deflection expected under the actual load;
 - f. Specified minimum static deflection;
 - g. The additional deflection-to-solid under load;
 - h. The ratio of spring height under load to spring diameter.
 3. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
 4. Special details necessary to convey complete understanding of the work to be performed.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION MOUNT TYPES

- A. General:
1. All mechanical equipment shall be mounted in accordance with the specifications below and for the specific requirements shown in the equipment schedule.
 2. The isolation manufacturer shall supply all unit isolators, complete rails, fan and motor bases and structural steel forms for concrete inertia blocks, where called for and shall be responsible for the selection of all vibration eliminators and shall guarantee to meet the requirements of these Specifications.
 3. Wherever rotational speed is mentioned as the disturbing frequency, the lowest speed in the system shall be used. All isolation devices shall be selected for uniform static deflections according to distribution of weight. Lateral motion of all isolators shall be 1/4" maximum during start-up and shut-down.
 4. All metal parts of vibration isolation units installed out-of-doors shall be cold-dip galvanized, cadmium plated, or neoprene coated after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14. Isolators shall be equipped with limit stops to resist wind velocity.
 5. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.

6. Isolator types are scheduled to establish minimum standards. At the Contractor's option, laborsaving 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 must not degrade the vibration isolation system.
7. Static deflection of isolators shall be as provided in SECTION 3 - EXECUTION. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.
8. All fan units and air handling units (except fans with wheels under 27") shall be isolated as follows:
 1. Up to 450 RPM: 75% efficiency (3-1/2" maximum deflection)
 2. 450 RPM to 850 RPM: 90%
 3. 850 RPM and over: 95%

Submittals shall show disturbing frequency, required efficiency, designed deflection and outside diameter of springs, when pertinent.

9. Weight of concrete inertia blocks shall be as follows:
 1. Fans and air handling units (up to 5" s.p.) driven by 75 HP and larger motors: 1-1/2 times weight of equipment.
10. All horizontal pipe connected to rotating equipment within the mechanical equipment room area, but not less than 50 feet from connected equipment shall be isolated from building structure by means of units designed for insertion in rods.

B. Type FSN (Floor Spring and Neoprene)

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts.
2. Either the spring element in the isolator shall be set in a neoprene cup and have a steel washer to distribute the load evenly over the neoprene, or each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, provide a rectangular bearing plate of appropriate size to load the pad uniformly within the manufacturer's recommended range.
3. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, the plate shall not be made of galvanized steel. The NP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.
4. If the isolator is to be fastened to the building structure and Type NP isolator is used under the bearing plate, neoprene grommets shall be provided for each bolt hole in the base plate. Bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers are to be galvanized.

Type FSN isolators shall be Mason Type SLF with the appropriate neoprene pad (if used) selected from Type NP or approved equal.

C. Type HSN (Hanger Spring and Neoprene)

1. Vibration isolation hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Hangers shall provide a means to adjust hanger elevation under load. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3" minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.

Type HSN isolators shall be Mason Type P30N or approved equal.

D. Type DSN (Double deflection spring and neoprene)

1. Vibration hangers shall contain a steel spring and a double deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection and be seated in a neoprene cup with an integral molded bushing that passes through the lower hanger box.

Type DSN isolators shall be Mason type DNHS or approved equal..

2.2 RESILIENT LATERAL GUIDES

- A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN which are specifically designed to provide resilient lateral bracing of duct or pipe risers.

Resilient lateral guides shall be Mason Type ADA.

2.3 FLEXIBLE DUCT CONNECTORS

- A. Flexible duct connection shall be made from coated fabric (or leaded vinyl if called for on the drawings). The clear space between connected parts shall be a minimum of 3" and the connection shall have 5" minimum of slack material.

2.4 FLEXIBLE PIPE CONNECTIONS

- A. Flexible pipe connection shall be fabricated of multiple plies of nylon cord, fabric, and neoprene; and shall be vulcanized so as to become inseparable and homogeneous. Flexible connections shall be formed in a double sphere shape, and shall be able to accept compressive, elongative, transverse, and angular movements.
- B. The flexible connections shall be selected and specially fitted, if necessary, to suite the system temperature, pressure, and fluid type. In addition, suitable flexible connections should be selected which do not require rods or cables to control extension of the connector.
- C. Connectors for pipe sizes 2" or smaller shall have threaded female union couplings on each end. Larger sizes shall be fitted with metallic flange couplings.

- D. Provide Mason Industries Type MFTNC or MFTFU; Metraflex Twin Sphere; or Amber/Booth Type 2600 or 2655 for flexible pipe connections less than 220°F and 150 psi.
- E. Flexible pipe connections shall be mason Industries Type BSS braided stainless steel hose with carbon steel fittings for pressures above 150 psi or temperatures greater than 220°F

2.5 RESTRAINTS

A. Snubber:

1. Snubbers shall be custom fabricated using Type FN isolators mounted to steel angle brackets. The steel angle shall be sufficiently rigid and the mounting sufficiently secure to resist excessive movement of equipment during on-off cycle.

B. Thrust Restraints:

1. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be precompressed at the factory to allow for a maximum of ¼" movement during starting or stopping of the equipment. Allowable movement shall be field-adjustable.
2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
3. Thrust restraints shall be Mason Industries Type WB, Kinetics Noise Control Type HSR, Amber/Booth Type TRK or an equal product of the manufacturer supplying the isolators.

2.6 GROMMETS

- A. Grommets shall either be custom made by combining a neoprene washer and sleeve, be Isogrommets as manufactured by MBIS, Inc. (Bedford Heights, Ohio), or be Series W by Barry Controls (Watertown, Mass.). Grommets shall be sized so that they will be loaded within the manufacturer's recommended load range. Grommets shall be specially formed to prevent both from directly contacting the isolator base plate.

2.7 ACOUSTICAL SEALANT

- A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the non-setting sealants indicated below:

Acoustical Sealant	D.A.P
BR-96	Pecora
Acoustical Sealant	Tremco
Acoustical Sealant	U.S.G.

PART 3 - EXECUTION

3.1 APPLICATION

A. General:

1. Refer to SECTION 2 - PRODUCTS of this specification for vibration isolation devices identified on the drawings or specified herein.

2. The static deflection 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.
3. Refer to Section 26 05 49 for seismic requirements.

B. Major Equipment:

1. Unless otherwise shown or specified, all floor-mounted major equipment shall be set on 4" high concrete housekeeping pads. Mount vibration isolating devices and related inertia blocks on concrete pads.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as scheduled on the drawings or specified hereunder.
3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the drawings.
4. Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment, refer to drawings for proper position.
5. Thrust restraints shall be installed on all floor-mounted fans developing 4" or more of static pressure, all suspended fans developing 2" or more static pressure, and wherever else called for on the drawings.
6. Snubbers shall be installed as called for on the drawings.
7. Brackets shall be provided to accommodate the isolator. The vertical position and size of the bracket shall be specified by the isolator manufacturer.

C. Miscellaneous Mechanical Equipment: Miscellaneous pieces of mechanical equipment such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks, and expansion tanks which are connected to isolated piping system shall be vibration isolated from the building structure by Type NP or Type HN isolators (selected for 0.1" static deflection) unless their position in the piping system requires a higher degree of isolation as called for under Pipe Isolation.

D. Pipes:

1. All chilled water, condenser water, heating water, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
 - a. Within mechanical rooms.
 - b. And within 50' total pipe length of connected vibration-isolation equipment (chillers, pumps, air handling units, pressure reducing stations, etc.):
2. Piping shall be isolated from the building structure by means of vibration isolation mounts, resilient pipe guides, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2" Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to 1/2", Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least 1/4" static deflection.
4. Where lateral support of pipe risers is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections on all piping connected to all isolated equipment and wherever shown on the drawings.

3.2 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts:

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides 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 to herein.
4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beam joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360° about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze, which is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and non-isolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide ¼" clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.

2. Unless otherwise indicated, there is to be a minimum operating clearance of 2" between inertia bases or steel frame bases and the floor beneath the equipment. Position isolator mounting brackets and adjust isolators so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.
- D. Flexible Duct Connections: Sheet metal ducts and plenum opening shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.
- E. Flexible Pipe Connections: Install flexible pipe connections in strict accordance with the manufacturer's instructions.
- F. Restraints:
1. Snubbers shall be adjusted to clear the equipment base and to provide lateral restraint during on-off cycling, but be out of contact during normal operation of the equipment.
 2. Thrust restraints shall be attached at the centerline of thrust and symmetrically on each side of the unit. The two rods of the thrust restraint shall be axially aligned. This may require modified brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.
- G. Resilient Penetration Sleeve/Seals:
1. Maintain an airtight seal around the penetrating element and prevent rigid contact between 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.
 - a. At minimum, provide resilient penetration seals at all Mechanical, Equipment and Fan Room Penetrations.

3.3 ISOLATOR SCHEDULE

UNIT	ISOLATOR TYPE	MINIMUM STATIC DEFL.(IN.)	BASE TYPE	REMARKS
Air Handling Units Suspended	DSN	0.35		Thrust restraints if internally isolated.
Fan Coil Units	(Note 2)	(Note 2)		
Refrigeration Reciprocating Compressors, Condensing Units or Chillers	FSN	1.5		
Utility Fans (Suspended)	HSN	2.0		

Notes:

- (1) External isolator may be omitted if units have internally isolated fans and no other rotating or reciprocating components.
- (2) Isolators for fan coil units should be either HSN with 0.75" minimum static deflection or be equivalent to Mason Industries Type HN with 0.35" minimum static deflection.

3.4 INSPECTION AND COORDINATION

- A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify Commissioner in writing of conditions detrimental to proper and timely completion of the Work.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected.
- C. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.
- D. Bring to the Commissioner's attention, prior to installation, any conflicts with other trades which may result in unavoidable rigid contact with equipment or piping as described herein, duct to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.
- E. Bring to the Commissioner's attention, any discrepancies between the Specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the Contractor's expense.

3.5 FIELD QUALITY CONTROL

- A. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.
- B. Upon completion of installation of all vibration isolation devices herein specified, the local representative of the isolation materials manufacturer shall inspect the completed system and report, in writing, any installation error, improperly selected isolation devices, or other faults in the system that could affect the performance of the system. Contractor shall submit a report to the Commissioner, including the manufacturer's representatives final report, indicating all isolation reported as improperly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

END OF SECTION

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SECTION 23 05 53**MECHANICAL IDENTIFICATION****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Submit manufacturer's product data on the following:
 - 1. Plastic Pipe Markers and method of application.
 - 2. Engraved Plastic Laminate Sign.

PART 2 - PRODUCTS**2.1 GENERAL**

- A. Except as otherwise indicated, provide manufacturer's standard products.
- B. Where more than a single type is specified for an application, selection is Installer's option, but provide a single selection for each application.

2.2 PLASTIC PIPE MARKERS (TYPE A)

- A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, color-coded, plastic-sheet pipe markers, complying with ANSI A13.1.
- B. For Pipes Less Than Six Inches (including insulation if any): Provide full-band pipe markers, extending 360° around pipe at each location, fastened by one of the following methods:
 - 1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
 - 2. Adhesive lap joint in pipe marker overlap.
 - 3. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than ¾" wide; full circle at both ends of pipe marker, tape lapped 1-½".
- C. For Pipes Six Inches and Larger (including insulation if any): Provide either full-band or strip-type markers, but not narrower than 3 x letter height, taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-½" wide; full circle at both ends of pipe marker, tape lapped 3".
- D. Lettering: Manufacturer's pre-printed wording which conforms to contract document system descriptions.
- E. Where work is an extension or alteration of an existing system, new markers shall match existing terminology for systems which are modified or added by this work.
- F. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering or as a separate unit of plastic (to accommodate both directions).

2.3 STENCILING (TYPE B)

- A. Using a color contrasting to the surface to identify, spray or brush paint through neatly cut stencils.
- B. Lettering shall conform to wording on contract documents. Size shall be in accordance with ANSI A13.1.

2.4 BACKGROUND COLOR AND STENCILING (TYPE C)

- A. In addition to the requirements above, paint a background color band in accordance with ANSI A13.1.

2.5 VALVES TAGS

- A. Brass Valve Tags: Provide manufacturer's standard 19 ga brass tag; approximately 1-½" round with ½" high black filled numbers and 3/16" top hole.
 - 1. Numbers shall be sequential in accordance with schedule below.
 - 2. Provide separate numbering for each legend sequence. Provide separate sequences for the following:
 - a. Gas (GAS)
 - b. All other systems (No legend)
- B. Valve Tag Fasteners: Manufacturer's standard chain (wire link or beaded type), or S-hooks.

2.6 VALVE SCHEDULE

- A. Provide schedule for each piping system, as defined on the drawings, and below, typewritten and reproduced on 8-½" x 11" bond paper.
- B. Tabulate valve number, piping system, system legend (as shown on tag), location of valve (room or space), and variations for identification (if any).
- C. Provide piping schematic for each system as defined below in Part 3.
- D. In addition to mounted copies, furnish extra copies for maintenance manuals as specified.
- E. Valve Schedule Frames: For each page of the valve schedule, provide a glazed frame, with screws for removable mounting on masonry walls.

2.7 ENGRAVED PLASTIC-LAMINATE SIGNS

- A. General: Provide engraving stock melamine plastic laminate, 1/16" thick, black with white core (letter color).
- B. Fastening:
 - 1. Screws
 - 2. Rivets
 - 3. Permanent Adhesive

C. Lettering and Graphics:

1. Coordinate names, abbreviations and other designations used in the mechanical identification work, with the corresponding designations shown, specified or scheduled in the construction documents.
2. In addition, for heating or cooling units and exhaust fans, identify area served.

PART 3 - EXECUTION

3.1 GENERAL

- A. Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, install identification after completion of covering and painting.
- B. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 DUCTWORK IDENTIFICATION

- A. **General:** Identify air supply, return, exhaust, intake and relief ductwork with stenciled signs and arrows, showing ductwork service and direction of flow, in black or white, whichever provides most contrast with ductwork color.
- B. **Location:** In each space where ductwork is exposed, or concealed only by removable ceiling system, locate signs near points where ductwork originates or continues into concealed enclosures (shaft, underground or similar concealment), and at 50' spacing along exposed runs.
- C. **Access Doors:** Provide stenciled or plastic laminate type signs on each duct or equipment mounted access door in ductwork and housings, indicating the purpose of the access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

3.3 PIPING SYSTEM IDENTIFICATION

- A. **General:** Install pipe markers on piping of the following systems and include arrows to show normal direction of flow.
 1. Heating water piping (supply and return).
 2. Refrigerant piping (suction, liquid, hot gas bypass).
 3. Steam piping (indicate pressure).
 4. Condensate piping.
 5. Boiler system piping (make-up, condensate, vent, chemical treatment).
 6. Any other piping system as indicated on the drawings, or as required to match existing.
- B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces above accessible ceilings, in accessible maintenance spaces, including chases, and above ceiling:
 1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where there could be a question of flow pattern.
 3. Near locations where pipes pass through walls, floors, or ceilings, or enter non-accessible enclosures.
 4. Near major equipment items and other points of origination and termination.
 5. Spaced intermediately at maximum spacing of 50' along each piping run.

6. Within 6' of access doors above otherwise non-accessible ceilings and chases.

C. Type:

1. Normally exposed to view - Type A or C.
2. Normally concealed from view - Type B.

3.4 VALVE IDENTIFICATION

- A. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory fabricated equipment units, hose bibs, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
- B. Mount framed valve schedules with piping schematics where directed by Commissioner.
- C. Identify each valve tagged on as-built drawings.

3.5 MECHANICAL EQUIPMENT IDENTIFICATION

- A. Install an engraved plastic laminate sign on or near each major item of mechanical equipment.
 1. Provide signs for the following general categories of equipment and operational devices:
 - a. Fans
 - b. Air Handling Units
 - c. Packaged Air conditioning Units (including Rooftop Units)
 - d. Motor Starters and Variable Frequency Drives (Mount near starter)
 - e. Boilers
 - f. Pumps

- B. Provide engraved plastic laminate nameplate on every new piece of equipment not already provided with one in accordance with Section 23 05 02 of the specifications.

- C. Identify area served, if applicable.

3.6 NON-POTABLE WATER IDENTIFICATION

- A. Provide an engraved plastic laminate sign.
 1. Legend: "Non-Potable Water".
 2. Location: At each outlet of piping downstream of backflow preventer, (e.g. Boiler Room hose bibb).

END OF SECTION

SECTION 23 05 93**TEST-ADJUST-BALANCE****PART 1 - GENERAL****1.1 RESPONSIBILITY**

- A. Work of this section shall be completed by a sub-contractor of the HVAC contractor.
- B. The Balancing Contractor shall not be a sub-contractor of any other Division 21, 22 or 23 Contractor.

1.2 QUALITY ASSURANCE

- A. Qualification:
 - 1. Work shall be done by a firm certified by the National Environmental Balancing Bureau (NEBB), or the Associated Air Balance Council (AABC), or the firm shall have technicians certified by the "National Training Fund Sheet Metal & Air Conditioning Industry".
 - 2. The firm shall be an independent testing and balancing firm specializing in testing and balancing of environmental systems.
 - 3. The firm shall have an experience record of not less than three (3) years experience in the TAB industry.
- B. Industry Standards: Comply with the following:
 - 1. HVAC Systems-Testing, Adjusting, Balancing published by Sheetmetal and Air Conditioning Contractors National Association, Inc. (SMACNA).
 - 2. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems published by National Environmental Balancing Bureau. (NEBB).
 - 3. ASHRAE Systems Handbook. Testing, Adjusting and Balancing.
- C. Registration: Work shall be done under the supervision of a professional engineer licensed in the jurisdiction of the work. Engineer shall be available for all meetings and interpretation of all materials in the report.
- D. Pre-qualification of TAB Contractor.
 - 1. The firm must have experience and qualifications satisfactory to the consulting mechanical engineer and must be accepted by him prior to bidding.
 - 2. Firms desiring approval to provide work under this section shall submit a booklet indicating procedures and data forms that they would use in the performance of the work.
 - 3. Submittals shall be in accordance with Section 23 05 02.
 - 4. Only firms which have been approved by the mechanical engineer may provide work under this section.

PART 2 - PRODUCTS**2.1 PRODUCTS (Not applicable)**

PART 3 - EXECUTION**3.1 GENERAL**

- A. Sequence work to commence after completion of system and start-up procedures and schedule completion of work before Substantial Completion of Project.
- B. Examine the installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned and is operable.
- C. Notify the Contractor in writing of conditions detrimental to the proper completion of the test-adjust-balance work.
 - 1. Do not proceed with the work until unsatisfactory conditions have been corrected.
 - 2. Provide Commissioner with a copy of the notification.
- D. Adjust flows to within 10% of values shown. If design flows cannot be obtained within specified limits the Balancing Contractor will perform the following (at the minimum):
 - 1. Measure and record major pressure drops in the system.
 - 2. Consult with the Engineer and Installer as required.
 - 3. Upon receiving written directions to proceed and after any corrections are performed, re-balance affected portion of system.
- E. Optimization: Work closely with the HVAC and controls contractor(s) to optimize setpoints.
 - 1. Establish the minimum air static pressure or water differential pressure for variable or bypass flow system.
 - 2. Establish the position of minimum outside air dampers, damper/valve and sequencing relays.
- F. Calibration: Be responsible for calibration of flow measurement devices used as input to the temperature control system. All air systems flow measurement stations shall be calibrated against a pitot tube traverse or air diffuser capture hood. Balancing contractor shall assure accuracy of all flow measurement devices or shall report on their failure to be accurate.
- G. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in a manner recommended by the original Installer.
- H. Make all final readings for each system at the same time, and after all adjustments have been made.
- I. Mark equipment settings, including damper control positions, balancing cocks, circuit setters, valve indicators, fan speed control settings and similar controls and devices, to show final settings at completion of test-adjust-balance work.
 - 1. Mark with paint or other suitable permanent identification material.
- J. Check all new thermal overloads.
 - 1. Identify improperly protected equipment in report.

- K. All piping and equipment shall be tested; labor including standby electrician, materials, instruments and power required for testing shall be furnished unless otherwise indicated under the particular section of the Specification.
- L. Tests shall be performed in the presence and to the satisfaction of the Commissioner and such other parties as may have legal jurisdiction.
- M. In no case shall piping, equipment, or accessories be subjected to pressure exceeding their ratings.
- N. All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Commissioner.
- O. Any damage resulting from tests to any and all trades shall be repaired and damaged materials replaced, all to the satisfaction of the Commissioner.
- P. The duration of tests shall be as determined by the New York City Department of Buildings and the New York City Building Code, but in no case less than the time prescribed below.
- Q. All fans and duct systems shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on the design drawings. Replace sheaves if required to meet design conditions.
- R. All pumps and piping systems shall be completely balanced by the adjustment of the plug cocks, globe valves or other control devices, to obtain the flow quantities indicated on the design drawings.

3.2 FIELD TEST OF PIPING

- A. During construction properly cap or plug all lines so as to prevent the entrance of sand, dirt, etc. The system of piping shall be blown through wherever necessary after completion (for the purpose of removing grit, dirt, sand, etc., from all equipment and piping), for as long a time as is required to thoroughly clean the apparatus.
- B. Use anti-freeze solution for piping to be tested in winter.
- C. All piping shall be tested as hereinafter specified. Tests shall be made after erection and before covering is applied or piping painted or concealed and as sections of mains and groups of risers are completed. The extent of the work completed before pressure tests are made shall be determined by the Commissioner.
- D. All piping, unless otherwise specified, shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum designed working pressure (but not less than 50 lbs. per sq. in) for a sufficiently long time to detect all leaks and defects; and after testing shall be made tight in the most approved manner. Tests shall be repeated once after leaks and defects have been repaired. When automatic-control valves and similar devices are incapable of withstanding test pressures applied to piping, such devices shall be removed, or otherwise protected during tests. After removal of such tests, devices shall be installed and tested with operating medium to operating pressures. The following shall be tested for four consecutive hours and proved tight. Leaks shall be remedied by replacing defective work.

<u>Item</u>	<u>Hydrostatic Field Test</u>
Low pressure steam and condensate piping	100 psi
Pumped low pressure condensate returns (discharge)	100 psi
High pressure vents (steam safety and relief)	300 psi
Cold Water (domestic)	100 psi
Gas	50 psi
Gas Vent	50 psi

- E. Leaks appearing during the various pressure tests shall be corrected by replacing all defective materials or welds and subsequent tests shall be made until the piping is found perfect. Caulking of screwed joints or peening of welds is prohibited. Wherever it is necessary to cut out a weld and the ends of the pipe cannot be conveniently brought together, then a short piece of pipe shall be fitted in and welded as approved by the Commissioner.
- F. Provide all other tests required by Building Department, Fire Department and other Authorities having jurisdiction.

3.3 RUNNING TEST OF PIPING SYSTEMS

- A. When directed, any section of the work, after it has been completed and otherwise satisfactorily tested, shall be put in actual operation and operated for a period of two days of 24 hours each, during which time any defects which may appear shall be remedied and any adjustment which may be necessary shall be made.
- B. During the time of the tests, repack all valves, make all adjustments and otherwise put the apparatus in perfect condition for operation, and instruct the Commissioner in the use and management of the apparatus.

3.4 TEST OF REFRIGERATION PIPING

- A. Refrigeration piping shall be tested in accordance with the recommendation of the refrigeration equipment manufacturer and in the following sequence for a period of 24 hours:
 - High Side - Nitrogen at 300 psi
 - Low Site - Nitrogen at 150 psi
 - Entire System - Freon at 5 psi
- B. No visible leaks, losses in pressure or increase in vacuum shall occur during test period.

3.5 STEAM BOILER TEST (LOW PRESSURE STEAM)

- A. Hydrostatically test the boiler to the boiler's rated working pressure and all defects shall be corrected to the satisfaction of the Commissioner. In addition, test the operation of the safety valves one ach boiler by gradually increasing steam pressure until the safety valves "pop".
- B. The tests shall be as follows:
 - Test 1 - At approximately 25 percent of rating.
 - Test 2 - At approximately 50 percent of rating.
 - Test 3 - At maximum rating, 100 percent of rating.
- C. Apply these tests in the manner and sequence approved by the Commissioner.

- D. All necessary labor, equipment and test instruments and fuel required for the tests shall be furnished at no additional cost to City of New York.

3.6 EQUIPMENT TEST

- A. Demonstrate that all equipment and apparatus fulfill the requirements of the specifications. All equipment shall be operated and tested for rated capacities and specified characteristics. Voltage and amperage readings shall be taken on all electric motors.

3.7 AIR LEAKAGE TEST FOR MEDIUM OR HIGH PRESSURE DUCTWORK

- A. The testing of all joints for air leakage after erection and the repair of any leaks are positive requirements. Leakage must be kept to a specified minimum. This test for air leakage is divided into two phases, namely, testing of individual vertical risers and testing of all branches. Provide all required instruments.
- B. Test shall be made at 7 inches water gauge static pressure. All risers, branches and runouts shall be tested after installation before insulation is applied and before the air mixing units are installed. The total allowable leakage for the entire system shall be no more than one (1) percent of the total system capacity.
- C. Equipment necessary for performing this test shall include a rotary hand blower calibrated orifice section and a "U" tube gauge board complete with cocks and rubber tubing. The test hookup as well as details for the fabrication of the orifice section shall be in accordance with the recommendation of the "High Velocity Duct Manual" of Sheet Metal and Air Conditioning Contractors National Association, Inc.

3.8 TEST PREPARATION AND PROCEDURE

- A. On initial startup, prior to any tests, check the rotation and running amperage of all fan and pump motors to prevent damage to equipment by overload.
- B. Final balancing must be done with all systems completely installed and operating, and after the automatic temperature controls have had their final adjustment.
- C. New, clean filters must be installed in all supply systems prior to balancing. Simulate a pressure drop of a 50% loaded filter for all testing.
- D. All water systems shall be completely filled and vented, and all strainers cleaned prior to balancing. Inspect expansion tanks for proper water level and operation of makeup water valves.
- E. All main supply air ducts shall be traversed, using a pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges.

A main duct is defined as either of the following:

1. A duct serving five or more outlets.
2. A duct serving two or more branch ducts.
3. A duct emanating from a fan discharge or plenum and terminating at one or more outlets.

The intent of this operation is to measure by traverse the total air quantity supplied by the fan and to verify the distribution of air to zones.

- F. Submit data in support of all supply, return, exhaust and relief fan deliveries by the following four methods:
 - 1. By summation of the air quantity readings at all outlets.
 - 2. By duct traverses of main supply ducts.
 - 3. By a rotating vane traverse across a filter or coil bank.
 - 4. By plotting RPM and static pressure readings on the fan curve. Air density corrections must be indicated.
- G. For return air and exhaust fans, summation and cut traversing shall be sufficient.
- H. Inspect all fan scrolls and remove objects or debris. Inspect all coils and remove debris or obstructions. Verify that all fire dampers are open.
- I. The supply air systems shall be completely balanced prior to the final balancing of the water systems.
- J. Upon completion of all air and water balancing, all duct dampers, plug valves and other throttling devices shall be marked in the final adjusted position.

3.9 AIR BALANCE

- A. All air systems to be balanced. Before any adjustments are made, check for:
 - 1. Dirty filters, coils or air intakes.
 - 2. Duct leakage
 - 3. Filter leakage
 - 4. Damper leakage or blockage
 - 5. Equipment vibration.
 - 6. Correct damper operation.
- B. Record the following design requirements for all fans and fan motors from the approved shop drawings:
 - 1. Air quantities – CFM
 - 2. Approximate fan speed – RPM
 - 3. Fan static pressure (total or external) - inches of water.
 - 4. Maximum tip speed – FPM
 - 5. Outlet velocity – FPM
 - 6. Fan brake horsepower
 - 7. Motor horsepower
 - 8. Volts, phases, cycles and amps at design conditions.
- C. Record the following data from all fans and fan motors installed at the project:
 - 1. Manufacturer, model and size
 - 2. Motor horsepower, service factor and RPM
 - 3. Volts, phases, cycles and full load amps
 - 4. Motor starter and heaters size
 - 5. Equipment Location

- D. All fans and duct system shall be completely balanced by the adjustment of sheaves, dampers, registers and other volume and diverting control devices, to obtain the air quantities indicated on the design drawings. Outside air and return air modulating dampers shall be adjusted to admit the specified quantities of air under all cycles of operation. All final adjusted air quantities shall be within 10% of the design requirements. Replace sheaves if required to meet design conditions.
- E. Record the following test data for all fans and fan motors installed at the Project at final balanced conditions:
1. Fan speed RPM
 2. Fan static pressure (external and total) inches of water
 3. Static pressure drops across all filters, dampers, coils and other items in the supply fan casings
 4. Motor operating amps
 5. Actual voltage
 6. Fan CFM
 7. Calculated brake horsepower
- F. Submit single line diagrams of all duct systems indicating all terminal outlets identified by number. Data sheets shall list all such outlets denoted by the same numbers, including the outlet size, "K" factor, location, CFM and jet velocity.
- Submit this data for all supply, return and exhaust air systems
- G. Adjust the outside air and return air dampers to admit the required amounts of air under both summer and winter cycles. Record, and submit, the outside, return and mixed air temperatures for both cycles after final adjustments.
- H. Measurements shall be made with system in normal, full load condition.
1. Systems with economizers shall be measured at minimum outside air and 100% outside air.
 2. Systems with 100% outside air capability or evaporative cooling sections shall be measured at maximum outside air.
 3. VAV systems shall be measured at the zone level at maximum air condition, and at the main at the system diversity condition.
- I. Make main duct traverses or coil/filter traverses and report operation at all other operating conditions (as applicable).
1. Economizer operation
 2. Unoccupied mode
 3. Smoke evacuation mode
 4. Pre-cool mode
 5. Fail over mode
 6. Two-speed fans
 7. All VAV terminals driven to maximum position
- J. Set fan speed such that under no condition will the motor exceed the service factor rating when operating in any of the above possible modes.
- K. Measure fan motor amps in each of the above possible operating modes (clean filters).

- L. Adjust Air Systems to provided proper air pressure relationships as shown by relative air quantities or as indicated on the drawings.
 - 1. Review drawings for room by room pressure relationships and use a smoke candle to prove proper relative air flow.
- M. Adjust distribution system for uniform space temperatures free from objectionable drafts and noise.
 - 1. Verify diffuser face orientation and blade angles with contractor and engineer prior to installation and balancing. Adjust blade angles as necessary to eliminate objectionable drafts in the occupied areas, seating bowl and concourses.
 - 2. Return to project after two events, as designated by Commissioner, to make any necessary balancing adjustments. Adjust blade angles as necessary to eliminate objectionable drafts in the occupied areas, seating bowl and concourses.
- N. Exchange sheaves and belts as required to adjust the rpm of all fans so they handle specified air quantity.
- O. Set minimum outside air quantities.

3.10 WATER BALANCE

- A. Before any adjustments are made:
 - 1. Check temperature control valve operation.
 - 2. Check pump rotation.
 - 3. Adjust pressure reducing valve.
 - 4. Remove any roughing strainer screens in systems.
- B. Record the following design requirements for all pumps and pump motors from the approved shop drawings:
 - 1. Water quantity – GPM
 - 2. Total head - feet of water
 - 3. Pump speed – RPM
 - 4. Impeller size
 - 5. NPSH (if required)
 - 6. Motor horsepower
 - 7. Volts, phases, cycles and amps at design conditions.

3.11 AIR SYSTEMS

- A. Scope: All air systems are to be balanced.
- B. Before any adjustments are made, check for:
 - 1. Dirty filters, coils, or air intakes
 - 2. Duct leakage
 - 3. Filter leakage
 - 4. Damper leakage, or blockage
 - 5. Equipment vibrations
 - 6. Correct damper operation

- C. Simulate a pressure drop across filters equal to that when 50% loaded with dust.
 - 1. Check fan motor amps with clean filters and simulated loaded filters, and report.
- D. Procedure:
 - 1. Measure and report all supply, return, exhaust, and outside air systems by means of (4) four methods:
 - a. Individual air inlets and outlets.
 - b. Pitot traverses of main supply, return, exhaust and outside air ducts.
 - c. Rotating valve or velocity grid traverse of coils or filters.
 - d. Plot operating point on fan curve. Include compensation for effects of altitude and inlet vanes.
 - 2. Above measurements shall be made with system in normal, full load condition.
 - a. First floor system shall be measured at minimum outside air and maximum outside air.
 - b. Systems with 100% outside air capability or evaporative cooling sections shall be measured at maximum outside air.
 - 3. Make main duct traverses or coil/filter traverses and report operation at all other operating conditions (as applicable).
 - a. Economizer operation
 - b. Unoccupied mode
 - c. Pre-cool mode
 - d. Fail over mode
 - e. Two-speed fans
 - 4. Set fan speed such that under no condition will the motor exceed the service factor rating when operating in any of the above possible modes.
 - 5. Measure fan motor amps in each of the above possible operating modes (clean filters).
- E. Adjust Air Systems to provided proper air pressure relationships as shown by relative air quantities or as indicated on the drawings.
 - 1. Review drawings for room by room pressure relationships and use a smoke candle to prove proper relative air flow.
- F. Adjust distribution system for uniform space temperatures free from objectionable drafts and noise.
 - 1. Division 23 33 00 to provide orifice plates or dampers where required.
- G. Exchange sheaves and belts as required to adjust the rpm of all fans so they handle specified air quantity.
- H. Set minimum outside air quantities.

3.12 DETAILED REQUIREMENTS

A. Measure, adjust and report the following:

1. Fans:
 - a. Inlet and outlet pressure
 - b. Air flow
 - c. Fan speed
 - d. Motor amps and KW
2. Ductwork Systems:
 - a. Air flow at each inlet and outlet.
 - b. Blade angles at all adjustable diffusers.
 - c. Filter pressure drop.
 - d. Outside air percentage at minimum and maximum setting.
 - e. Air flow at supply, return, outside air and exhaust mains to determine total air flow.
3. Coils:
 - a. Air flow.
 - b. Inlet and outlet air static pressure.
 - c. Inlet and outlet air temperature.
 - d. Water flow.
 - e. Inlet and outlet water pressure.
 - f. Inlet and outlet water temperature.
 - g. Kw draw on electric coils.
4. Radiation and Convectors:
 - a. Inlet and outlet water temperature
 - b. Air temperature (room)
 - c. Water flow
5. Heating Boiler(s): Check at full fire.
 - a. Inlet and outlet water temperatures
 - b. Water flow
 - c. Stack temperatures
 - d. Gas pressure and cubic feet of gas per hour Percent CO₂ and O₂
 - e. Combustion efficiency
 - f. If boiler is equipped for variable firing rates, include data for a. through e. for maximum and minimum firing rates.
 - g. Manufacturers start-up report may be substituted if all above measurements are included.
6. Cabinet Heaters, Unit Heaters:
 - a. Entering air temperature
 - b. Leaving air temperature
 - c. Inlet and outlet water temperature
 - d. Water flow
7. Air-Cooled Condensing Units:
 - a. Ambient temperature
 - b. Suction and discharge pressure
 - c. Oil pressure
 - d. Compressor amps and KW
 - e. Fan amps and KW

8. Blower Coil Unit
 - a. Perform tests for individual components present in units in accordance with specific requirements above.
 - b. At full heat: (Check at minimum outside air):
 - 1) EAT
 - 2) LAT
 - 3) Supply Fan (CFM, Amps)
 - c. At full cooling: (Check at minimum outside air):
 - 1) EAT (DB/WB)
 - 2) LAT (DB/WB)
 - 3) Supply Fan (CFM, Amps)
 - 4) Suction and discharge pressures
 - 5) Compressor amps and KW

3.13 REPORT

- A. Provide a general information sheet listing:
 1. Instruments used:
 - a. Most recent calibration date.
 2. Method of balancing.
 3. Altitude correction.
 4. Manufacturer's performance data for all air devices used.
- B. Provide data sheets for all equipment, including motors and drives, listing:
 1. Make
 2. Size
 3. Serial number
 4. Capacity Rating
 5. Amperage
 6. Voltage input
 7. Thermal heater size for each motor
 8. Operating speed of driver and driven devices
 9. Any additional pertinent performance data
- C. Include design and final values for all items listed in Detailed Requirements, and totals for each system.
- D. Provide data sheets showing:
 1. Air flow at each inlet and outlet
 2. Instrument used
 3. Velocity reading
 4. Manufacturer's free area factors
- E. Provide recap sheet with explanation for each device not meeting specified performance. Contractor shall be responsible for correcting all deficiencies noted in the TAB report. Upon completion of correction of deficiencies, the TAB contractor shall retest all devices and provide an updated report.
- F. Provide a set of prints with equipment, inlets and outlets marked to correspond to data sheets.

END OF SECTION

SECTION 23 07 00**MECHANICAL INSULATION****PART 1 - GENERAL****1.1 SUBMITTALS**

- A. Submit manufacturer's product data on the following:
 - 1. Insulation.
 - 2. Jackets, coatings and protective finishes.
 - 3. Sealers, mastics and adhesives.
 - 4. Fitting covers.
 - 5. Manufacturer's installation details for fire rated duct wrap.

1.2 FLAME AND SMOKE RATINGS

- A. Provide insulation tested on a composite basis (insulation, jacket, covering, sealer, mastic and adhesive) complying with the following for:
 - 1. Flame Spread: 25 or Less
 - 2. Smoke Developed: 50 or Less
 - 3. Fuel Contributed.....50 or less
 - 4. Method: ASTM E84 (NFPA 255), UL 723
- B. Accessories such as adhesives, mastics, cements, tapes and cloths for fittings shall have component ratings as listed above. All products shall bear UL labels indicating the above are not exceeded.

1.3 PRODUCT DELIVERY

- A. Deliver insulation products in factory containers bearing manufacturer's label showing fire and smoke hazard rating, density and thickness.
- B. Protect insulation against, dirt, water, chemical and mechanical damage. Do not install damaged insulation; remove from project site.
- C. Store insulation in original wrappings and protect from weather and construction traffic.

1.4 DEFINITIONS

- A. Exposed Location: Located in mechanical rooms or other areas exposed to view.
- B. Concealed Location: Located in pipe chases, furred spaces, attics, crawl-spaces, above suspended ceilings, or other locations not exposed to view.

1.5 STANDARDS

- A. Comply with the latest edition of National Commercial and Industrial Insulation Standards.
- B. Provide certifications or other data as necessary to show compliance with these Specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

PART 2 - PRODUCTS**2.1 PIPE INSULATION****A. Manufacturers:**

1. Design Basis: Johns-Manville
2. Other Acceptable Manufacturers:
 - a. Armstrong
 - b. Foster
 - c. Owens-Corning
 - d. Knauf
 - e. Nomaco
 - f. Imcoa
 - g. Pittsburgh Corning
 - h. Cell-U-Foam

B. Materials:

1. Fiberglass Pipe Insulation with Vapor Barrier: Johns-Manville Micro-Lok heavy density pipe insulation with AP-T jacket or Owens-Corning Fiberglass Corp. ASJ/SSL-II.
2. Fiberglass Pipe Fitting Insulation: Johns-Manville "Zeston" fitting covers with factory-cut fiberglass insulation insert. Insulation blanket with foil tape and tie-wire will not be acceptable.
3. Flexible Unicellular Pipe Insulation: Armstrong Armaflex, II or Therma-cel By Nomaco.
4. Cellular glass with vapor barrier coating: Pittsburgh Corning.
5. Rigid Closed Cell Insulation: Dow Trymer 2000 (not for use indoors).

C. Thickness: (Thickness listed below are minimum required. Provide thickness required by Local Building or Energy Codes)

1. Steam
 - a. For pipes less than or equal to 1½" diameter, insulation = 1½"
 - b. For pipes greater than 1½" in diameter, insulation = 3"
2. Steam Condensate:
 - a. Size 1¼" to 2": 1½"
 - b. Size over 2": 2"
3. Refrigerant Suction, Refrigerant Liquid and Hot gas Bypass Lines:
 - a. Size 1-1/2" and smaller: 1"
 - b. Exposed in occupied areas: 1½"
4. Repairs to Existing Insulation: Match thickness of existing insulation.
5. All Heat Traced Piping:
 - a. Size 2" and smaller: 1"
 - b. Size 2½" and larger: 2"

D. Application: Unless otherwise indicated, use the following:

1. Inside, above ground: Fiberglass with a maximum K factor of 0.22 BTU/inch per sq. ft. per degree F. per hour at 75°F. mean temperature with factory-applied all service vapor proof jacket. Density shall be not less than 3 lbs. per cubic foot. For hot pipe insulation, insulation shall be suitable for 650°F. (2" minimum thickness above 450°F).
2. Inside exposed: Fiberglass with PVC jacket (jacket not required in mechanical rooms).
 - a. A vapor barrier mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side.
 - b. 2 or more layers of the Hi-Lo Temp insulation inserts shall be applied with the first layer being secured with a few wrappings of fiberglass yarn.
 - c. Refrigerant systems and cold systems in severe ambient conditions: Fittings shall be insulated to a full thickness the same as the adjacent pipe insulation, with insulation which has been mitered to conform to the PVC fitting cover. An intermediate vapor barrier compatible with the PVC shall be applied, completely sealing the insulation and on the fitting cover overlap seam. The PVC fitting cover is then applied and shall be secured with pressure sensitive pearl gray Z-Tape along the throat seam and the circumferential edges overlapping itself 2" on the downward side.
 - d. Qualifications for Using Insulation: When the pipe insulation thickness is greater than 1-1/2" or the pipe temperature is greater than 250°F or less than 45°F, additional insulation inserts should be used. Use one Hi-Lo Temp insert for each additional 1" of pipe insulation.
 - e. Fitting Cover: the temperature of the PVC fitting cover must be kept below 150°F by the use of proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.
3. Outside, protected: Fiberglass with aluminum jacket.
4. Outside, exposed to weather: Rigid closed cell with aluminum jacket.
5. Below grade or slab:
 - a. Pipe size 1½" and less: Single piece of flexible closed cell insulation slipped over soft annealed copper tube without slitting insulation.
 - b. Pipe size 2" and larger: Rigid closed cell insulation with shrink fit jacket.
6. All fittings, valves and flanges for pipe sizes 3" and below shall be insulated with preformed molded fiberglass insulation of same thickness as the adjoining pipe insulation, secured with No. 20 gauge galvanized annealed steel wire covered with Zeston 2000 molded PVC fitting covers as manufactured by Manville, or equal.
7. All fittings, valves and flanges for pipe sizes 4" and larger shall be insulated with fabricated mitered segments of pipe insulation of same thickness as the adjoining pipe insulation, secured with no. 20 gauge galvanized annealed steel wire and covered with Zeston 2000 molded PVC fitting covers as manufactured by Manville or equal.
8. Direct contact between pipe and hangers will not be accepted. Hangers shall pass outside of a metal saddle which shall cover a section of high density insulation of sufficient length to support pipe without crushing insulation. Hangers shall not pierce insulation and all vapor barriers shall be unbroken and continuous. High density insulation shall be one of the following:
 1. Foam glass.
 2. Fiberglass, high density, minimum of 7 lb. material or heavier.
 3. High density calcium silicate insulation. See Part 3 of this Section for high

density insulation lengths.

9. At pipe supports insulation shield protection saddles and matching hanger shall be used.
10. All strainers for chilled water and insulated condenser water piping shall be insulated and boxed in with galvanized sheet metal cover, and insulation shall be made removable.
11. The Contractor shall have the option to use 3/4" thick Armaflex II as made by Armstrong co. pipe insulation in lieu of fiberglass hereinbefore specified for chilled and hot water piping insulation in fan coil units. Pipe insulation shall meet flame spread index of 25 and smoke density of 100 when tested in accordance with ASTM-E-84.
12. Provide vapor barrier dams at locations and intervals recommended by the insulation manufacturer and as described in this specification.

2.2 DUCT INSULATION

A. Manufacturer:

1. Design Basis: Johns Manville
2. Other Acceptable Manufacturers:
 - a. Certainteed
 - b. Knauf
 - c. Owens-Corning

B. Materials:

1. Flexible Faced fiberglass Ductwork Insulation: Johns-Manville Microlite, with FSK factory applied foil-scrim-kraft facing.
2. Rigid Fiberglass Ductwork Insulation: Johns-Manville 800 Series, Spin-Glas Type 814, 3 lb. Density rigid board with FSK jacket.
3. Flexible Plain Fiberglass Ductwork Insulation: Johns-Manville Microlite .75 lb/cu. Ft. unfaced.
4. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles, and similar accessories as recommended by the insulation manufacturer for the applications indicated.
5. Cellular glass: Pittsburgh Corning with vapor barrier.
6. Flexible duct insulation with vapor barrier shall be 1-1/2 lbs. per cu. ft. density glass fiber with a maximum K factor of 0.25 at 75°F. mean temperature, with reinforced foil-faced flame resistant Kraft vapor barrier. Insulation with vapor barrier shall be duct wrap insulation FRK-25, type 100 as made by Owens-Corning or Manville Microlite with FRK vapor barrier facing or standard duct insulation as made by CGG with FRK facing.
7. Flexible duct insulation without vapor barrier shall be 1-1/2 lbs. per cu. ft. density glass fiber with a maximum K factor of 0.25 at 75°F. mean temperature and shall be Owens Corning Fiberglass Type 75P, Manville Microlite or equal.
8. Rigid duct insulation with vapor barrier shall be 4 lbs. per cu. ft. density glass fiber with maximum K factor of 0.22 at 75°F. mean temperature with fire retardant vapor barrier facing all service jacket (white finish). Rigid duct insulation with vapor barrier shall be Fiberglass Type 705 by Owens-Corning or Manville, Type 475 or Type 800 Micro-Aire with FSK facing or equal.
9. Rigid duct insulation without vapor barrier shall be 4 lbs. per cu. ft. density glass fiber with maximum K factor of 0.22 at 75°F. mean temperature. With fire retardant facing foil

reinforced draft (all service jacket). Rigid duct insulation without vapor barrier shall be Fiberglass type 705 by Owens-Corning or Manville, No. 817 w/ASJ or approved equal.

C. Application:

1. Insulate all exposed unlined supply ductwork with 1" thick rigid fiberglass (minimum R = 5).
2. Insulate all concealed unlined supply duct with 1-½" thick flexible, faced fiberglass (minimum R = 5).
3. Insulate all concealed unlined ductwork, transporting outside air with 1½" thick flexible fiberglass (minimum R = 5).
4. Insulate all concealed unlined supply and return ductwork installed within intake/relief/exhaust shafts with 2" thick flexible fiberglass (minimum R = 5).
5. Where energy codes require additional insulation over that listed above, provide insulation in accordance with those codes.
6. All ductwork located outside of the building envelope shall be insulated with a minimum R=8 insulation.
7. The Contractor shall have the option to use the following material: Insulation for round ducts shall be of thickness noted above and shall be fiberglass Bend-a-Board having a factory applied ASJ vapor barrier jacket secured with staples and ASJ pressure sensitive tape. Bend-a-Board is a 3.00 p.c.f. board cut into strips, adhered to jacketing it must have a UL label.
8. Additionally, secure insulation to bottom of rectangular ducts over 24" wide with welded pins or stick clips on 18" centers coated with a vapor barrier coating.
9. Rigid duct insulation shall be fastened to duct with 12 gauge welded pins and washers, or equivalent as approved. Fasteners shall be spaced 12 to 18 inches on center, a minimum of two rows per side of duct. Secure insulation in place with suitable speed washers firmly embedded in insulation, or push a self-locking cap over pin after coating with fitting mastic type C by Owens-Corning or equal. For rigid duct insulation, seal all joints, breaks and impressions with Foster fire resistant vapor barrier adhesive Benjamin Foster 82-07, or equal, and apply 5" wide joint sealing tape to all joints. All surface must be clean and dry before applying tape.
10. Insulation for exposed round ductwork shall be of the same material as specified for concealed ductwork and shall be covered with glass cloth or all service jacket smoothly adhered with Benjamin Foster 85-20 adhesive. Seal joints with 5" wide tape.

D. Duct Liner:

1. See Section 23 31 13, for duct liner requirements. Supply, return and outside air ductwork that is not lined is to be externally insulated.

2.3 OUTDOOR DUCT INSULATION

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
 - a. Johns-Manville
 - b. Nomaco

B. Materials:

1. Model: Armaflex
 - a. Description: Flexible, cellular, elastomeric foam.
 - b. Form: Sheet
2. Paint: Armaflex Finish
 - a. Description: Vinyl lacquer. Contractor must coordinate color of vinyl lacquer with Commissioner. Submit color chart to Commissioner for his review.
3. Adhesive: Armstrong 520.
4. Cellular glass: Pittsburgh Corning with vapor barrier.
5. Weatherproofing Finishes for Outdoor Round Duct Insulation:
 - a. Finished with Aluminum Jacketing with factory applied moisture barrier as manufactured by the Premetco Aluminum Jacket, or approved.
 - b. Al-Cor-Jac (.010 inch thick) with bonded polyethylene moisture barrier shall be used.
6. Outdoor rectangular ductwork shall be finished with Marathon Vi-AC Mastic, I-C 551, Gray (or color as selected by Commissioner).

C. Application:

1. All outdoor supply, return and transfer air ducts that are specified with acoustical duct lining shall be provided with 2" duct lining (minimum R=8).
2. All outdoor supply, return, and transfer air ducts that are not specified to have acoustical lining shall be insulated with two layers of one inch thick sheet on the exterior.
3. Jacketing shall be applied with minimum 2 inch overlaps facing down from the weather and the jacketing shall be secured with aluminum bands 1/2 inch by 0.020 inches and aluminum wing seals applied on 12 inch centers, with bands applied directly over butt overlaps or with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure-Joint 405.
4. Over the insulated surface apply a tack coat of Vi-AC Mastic and imbed in it a layer of Vi-AC, glass cloth. A smooth finish coat of Vi-AC Mastic shall be applied to the entire area so that the total film thickness is a minimum of 1/8 inch. Provide high point at center, so that no water accumulation will occur.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Verify acceptability of all materials which are to be used in air plenums (above ceiling, etc.). Materials must meet all requirements of Local Building Code and Authority having jurisdiction.
- B. Insulation Packing:
 1. Piping :
 - a. Wherever piping penetrates walls, partitions, floor slabs, etc., the space between the piping and the sleeve shall be packed with mineral wool and sealed with approved type non-hardening caulking compound for sleeves through exterior walls.

2. Ductwork:

- a. Provide 1/2" thick rigid fiberboard sleeve wherever ductwork penetrates walls, floor slabs, partitions, etc. Space between duct and wall sleeve and between duct and slab opening shall be tightly packed with mineral wool and sealed with approved type non-hardening caulking compound.

3. Material:

- a. Packing material shall be rockwool insulation as manufactured by United Stated Gypsum Co. or equal and shall comply with Fed. Spec. HH-1-558, Form A, Class 4, K=0.24, melting point 2000°F.

C. All Winterized Lines That Are Electrically Traced

- 1. The basic insulation shall be dual temperature, Manville Micro-Lok piping insulation, 1-1/2" thick. The insulation shall be sized to accommodate the electric heat tracing applied against the pipe surface.
- 2. Finish for insulation shall be aluminum jacket as specified under "Weatherproofing of Piping".

D. Contractor shall examine location where this insulation is to be installed and determine space conditions and notify the Commissioner in writing of conditions detrimental to proper and timely completion of the Work.

E. Do not proceed with the Work until unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION

- A. Install insulation in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that insulation complies with requirements and serves intended purposes.
- B. Coordinate with other work as necessary to interface installation of insulation with other components of systems.
- C. All insulating materials shall be applied only by experienced workmen, in accordance with the best covering practice. All piping, duct or equipment shall be blown out, cleaned, tested and painted prior to the application of any covering. Adhesives, sealers and mastics shall not be applied, when the ambient temperature is below 40°F., or surfaces are wet.

3.3 PIPE INSULATION

A. Insulate the following:

- 1. Heating piping.
- 2. Refrigerant suction lines.
- 3. Steam and condensate piping.
- 4. All existing piping which is currently insulated and which is modified as a result of this work.
- 5. Condensate drain piping.

6. Heat traced piping

B. Installation:

1. Install insulation on pipe system subsequent to testing and acceptance of tests.
2. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete the run. Do not use cut pieces or scraps abutting each other.
3. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
4. Extend piping insulation without interruption through pipe clamps, hangers, walls, floors and similar piping penetrations, except where otherwise indicated. Notched insulation will not be acceptable.
5. Install protective metal shields and saddles where needed to prevent compression of insulation. Refer to Section 23 05 29.
6. Except as noted, cover valves, flanges, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run.
 - a. Install factory-molded, pre-cut or job-fabricated units (at Installer's option), except where a specific form or type is indicated.
 - b. Do not cover:
 - 1) Valve operators.
 - 2) Nameplates or identification tags.
 - c. Provide removable access for:
 - 1) Strainers.
 - 2) Other components requiring access for service.
7. Mark location of unions and flanges covered by insulation with permanent paint or ink, or approved label.
8. Maintain integrity of vapor-barrier jackets on insulation of cold pipes and storm drainage piping, and protect to prevent puncture or other damage. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.
9. Inserts shall be installed at hangers for insulated piping. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapor barrier where required. Insulation inserts shall not be less than the following lengths:

2-1/2" pipe size and smaller	6" long
3" to 6" pipe size	9" long
8" to 10" pipe size	12" long
larger than 10" pipe size	18" long
10. Provide 18 gauge galvanized metal shields between hangers or supports and pipe insulation. Form shields to fit insulation. Extend shields up to centerline of pipe. Make shields same length as that specified above for inserts.
11. Where insulation is specified for piping, insulate similarly all connections, vents, drains, and any piping connected to system.
12. Fill surface imperfections such as chipped edges, small joints or cracks and voids or holes with insulation material and smooth all such areas with a skim coat of insulating cement.
13. Seal ends of sections with vapor barrier cement to create moisture dams at:
 - a. 20 ft. intervals.

- b. Valves and fittings.
- c. All hangers and supports.
- 14. On underground pipe insulation, install unicellular insulation on pipe without slitting insulation. Seal all transverse joints with adhesive.
- 15. Replace existing insulation removed or damaged because of work of this project.
- 16. Insulate new pipes and replace insulation on existing pipes to remain where insulation was removed or damaged by demolition or revisions.
- 17. Do not insulate steam traps.
- 18. Insulate between fingers of spiders in alignment guides.
- 19. Insulate between pipe and pipe saddle.
- 20. Perform all work in a neat and workmanlike manner. Poor work (as determined by Commissioner) will be cause for rejection.
- 21. Insulate all acid waste/vent pipe in return air plenums with Armstrong AP Armaflex.
- 22. Specialties shall be insulated to match those of the systems to which they are connected.
- 23. No insulation shall be installed until the piping systems have been hydrostatically tested as specified elsewhere to the satisfaction of the Engineer.
- 24. Provide glass cloth and aluminum bands 18" on center on calcium silicate insulation jacket and flared-out staples on all fiberglass hot pipe insulation. Tape vapor barrier joints and seams on all cold pipe insulation.
- 25. Provide 1" insulation on all horizontal runs of condenser water piping running over occupied areas to avoid condensation on pipe surfaces during winter operation of the Water Side Economizer.
- 26. Provide extended valve stems to maintain vapor barriers on all chilled water valves as required.

3.4 DUCTWORK INSULATION

- A. Insulate all ductwork except the following portions of ductwork:
 - 1. Ducts and casings internally insulated or provided with sound absorptive lining.
 - 2. All exhaust ductwork, except where otherwise noted.
 - 3. Return air ductwork from air conditioning systems passing through air conditioned space and/or hung ceiling of air conditioned space.
 - 4. Return air ductwork from heating and ventilating systems, where return air ducts pass through heated areas.
 - 5. Exposed air conditioned supply and return air ducts in air conditioned spaces if same supply or return air ducts serve that area only.
 - 6. Exposed supply air duct from heating and ventilating systems, if same duct serves that area only.
- B. Except where otherwise noted, all concealed rectangular and round ductwork shall be covered with flexible duct insulation with or without vapor barrier.
- C. Install insulation materials with smooth and even surfaces, after inspection and release for insulation application. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- D. Clean and dry ductwork prior to insulating.
- E. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

- F. Except as otherwise indicated, do not insulate lined ducts. However, extend duct insulation 12" beyond start of lining where lined ductwork meets insulated ductwork.
- G. Maintain integrity of vapor-barrier on insulation of ducts carrying cold air, and protect it to prevent puncture and other damage. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.
- H. Do not install covering before ductwork has been tested and approved.
- I. The finish including any vapor barrier treatment shall lap adjacent sections at both the transverse and longitudinal joints and 3" strips of matching finish material shall be adhered at the transverse joints.
- J. For Outdoor Armaflex Insulation:
 - 1. Stagger joints on multilayer applications.
 - 2. Locate joints at sides of ducts whenever possible.
 - 3. Use 520 adhesive to attach insulation. Provide full coverage.
 - 4. Seal all seams and joints with adhesive.
 - 5. Maintain full thickness at standing seams and flanges by additional layer(s).
 - 6. Cover flexible connections.
 - 7. Extend covering to inside face of outside wall.
 - 8. Finish with two coats of Armaflex finish.
- K. The installer of the ductwork insulation shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.
- L. Ductwork directly connected to ovens shall be insulated to the requirements for breeching.

3.5 EQUIPMENT INSULATION

- A. Install insulation materials with smooth and even surfaces and on clean and dry surfaces, after inspection and release for insulation application.
 - 1. Re-do poorly fitted joints.
 - 2. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.
- B. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- C. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
- D. Do not insulate handholes, cleanouts, ASME stamp and manufacturer's nameplate. Provide neatly beveled edge at interruptions of insulation.
- E. Insulation for factory-fabricated air handling units, furnished as part of units.

3.6 PROTECTION AND REPLACEMENT

- A. Replace damaged insulation which cannot be repaired satisfactorily. Including units with vapor barrier damage and moisture saturation. The insulation installer shall advise the Contractor of required protection for the insulation work during the remainder of the construction period, to avoid damage and deterioration.

3.7 ASBESTOS REMOVAL

- A. In the event asbestos is encountered the Contractor shall immediately cease work in the area of the asbestos shall contact the Commissioner's Abatement Contractor for instructions.
- B. Site Monitoring:
 - 1. Follow Section 1910.1001 Code of Federal Regulations Title 29, Part 1910 (OSHA Asbestos Regulations).
 - 2. Provide daily sampling during removal instead of at six month intervals.
 - 3. Stop work and notify Commissioner immediately if levels exceed those of Subparagraphs b (2) or b (3) of regulations.

END OF SECTION

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SECTION 23 09 00**BUILDING AUTOMATION AND AUTOMATIC
TEMPERATURE CONTROL SYSTEMS****PART 1 – GENERAL****1.1 GENERAL REQUIREMENTS**

- A. This Section is coordinated with and complementary to the General Conditions and Supplementary General Conditions of the Work, wherever applicable to Mechanical Work.
- B. Section 23 05 02 – Basic Mechanical Requirements shall apply.

1.2 DESCRIPTION

- A. The work described under this division is for all labor, materials, and equipment required for the construction of the Automatic Temperature Control (ATC) system.
- B. The system shall be complete in all respects, tested and ready for operation.
- C. All materials, equipment and apparatus shall be new and of first-class quality.
- D. Electrical Standards: Provide electrical products which have been tested, listed and labeled by Underwriters' Laboratories and comply with NEMA standards, The Building Code of the City of New York, and the National Electric Code.
- E. "Operator" is defined as the Commissioner designated to operate the BMS/ATC system after Commissioner acceptance.
- F. The work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Commissioner, a building automatic system as shown on the drawings and hereinafter specified.
- G. The Building Automation System shall be provided by the same manufacturer as the automatic temperature controls.
- H. The Automation System subcontractor shall furnish and install all equipment, accessories, wiring and instrument piping required for a complete and functioning system.
- I. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use.
- J. The Work includes the providing of all labor, materials, equipment, accessories, services and tests necessary to complete the place into satisfactory operation a complete system of automatic temperature controls as shown on the Drawings and hereinafter specified.
- K. The control system shall be of the electronic fully modulating type unless otherwise indicated, or as hereinafter specified. Control equipment shall be as manufactured by Andover, Siemens, Johnson Controls, Inc., or Honeywell, Inc. All controls shall be the product of one manufacturer. The temperature control manufacturer shall be responsible for the quality and satisfactory operation of material provided even if not actually manufactured by him.

- L. The control system shall include all necessary temperature sensors, damper motors, relays, sensors valves, etc., and all necessary equipment for a complete control system, regardless of whether or not specifically mentioned.
- M. The control system shall include all control and interlock wiring. The control wiring shall include all wiring, including power wiring for sensors, controls, control devices, relays, freezestats, firestats and all other necessary equipment to provide a complete control system, regardless of whether or not specifically mentioned, unless otherwise shown on the electrical drawings, including electric relays and contactors required for control interlocking. Interlock wiring shall include interlocks between fan starters between pump starters between starters and remote condensing units, between pumps, chillers and cooling towers and wherever else called for in these specifications. Unless otherwise noted; all control circuits shall be 120 volts or less.
- N. Provide nameplates on all devices, whether or not mounted on the face of local control panels. In occupied areas, nameplates shall be concealed beneath covers of room type instruments, to describe functions.

1.3 GENERAL INSTRUCTIONS

- A. The BMS/ATC systems as specified herein shall be provided in their entirety by the BMS/ATC Contractor. The BMS/ATC Contractor shall base his Bid on the systems as specified.
- B. The general provision of the contract (General Conditions and sections 23 05 01, 23 05 02, and 23 05 03) apply to work specified in this section.

1.4 QUALITY ASSURANCE

- A. Only firms regularly engaged in manufacture and installation of this equipment with characteristics and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years shall be acceptable.
- B. The entire building automation system shall be installed by skilled electricians and mechanics, all of whom are properly trained and qualified for this work. All wiring shall be installed in accordance with the Project Electrical Specifications.
- C. Supervision and checkout of the system shall be by factory-trained engineers and technicians directly employed by the automation Contractor.
- D. Provide system produced and installed by the manufacturers, which are listed in Section "Approved Manufacturer's List".
- E. Provide equipment which performance, under specified conditions, is certified by the manufacturer.

1.5 SCOPE

- A. The proposal shall be based on an electronic system. Valve and damper actuators shall be electronically actuated. Provide electronic sensors and transmitters with full DDC capabilities.
- B. The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ATC systems, as specified hereafter, shall be provided under this division by the BMS/ATC Installer.

- C. The BMS Contractor shall guarantee that the installed system is capable of maintaining the following comfort goals in conditioned areas served by the BMS.
 - 1. Space Design Temperature +/- 1°F.
 - 2. The BMS Contractor is not responsible for improper installation by other Divisions, however the BMS Contractor is responsible for informing the Construction Manager and Engineer of any requirements of this specification or any installation problem which prevents these goals from being maintained.
- D. The contractor shall be responsible for all power and control wiring for BMS equipment including BMS panels, actuators, dampers, controllers, control power transformers, relays, etc. work shall be sub-contracted to a licensed electrical contractor by the BMS contractor if the BMS contractor is not suitably licensed. All work shall be completed in accordance with the electrical specification sections of this specification

1.6 ITEMS REQUIRED TO BE COORDINATED WITH OTHER DIVISIONS

- A. Be responsible for coordinating the following:
 - 1. Power requirements (voltage, amps, location) for all BMS equipment requiring power. See Section 23 05 01.
- B. Installation and connection of all power wiring. Power wiring shall be defined as follows:
 - 1. Wiring of power feeds through all disconnect starters and variable speed controllers to electric motors.
 - 2. 120 VAC Emergency and 120V Normal power feeds to all BAS temperature control panels and equipment.
 - 3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by the BAS/ATC Contractor.
- C. Note that 120V to 24V surge protected transformers for low voltage wiring by this Division shall be furnished, set in place and wired (from designated circuit in electrical panel) by this Division, and all low voltage control wiring shall be installed under this Division.

1.7 WORK BY OTHERS

- A. The following work shall be provided under separate divisions of the specifications:
 - 1. Installation of all line size and non-line size automatic valves and separable wells. However, these devices shall be furnished under this division.
 - 2. Provision of all necessary piping connections, taps and direct-contact wells required for flow, pressure or temperature devices specified under other divisions.
 - 3. Provision of manual balancing dampers as specified under other divisions of Divisions 21 through 23.
 - 4. Installation of all automatic control dampers shall be by HVAC Contractor. All control dampers shall be furnished under this division.

1.8 AGENCY LISTINGS

- A. UL 916 PAZX Energy Management Systems.
- B. FCC-Part 15 Subparagraph J. Class A. Emissions requirements.
- C. UL-864/UUKL Smoke Removal.

1.9 RELATED SECTIONS

- A. 23 05 01 - Mechanical and Electrical Coordination.
- B. 23 05 02 - Basic Mechanical Requirements.
- C. 23 05 03 - Basic Mechanical Materials and Methods.

1.10 BMS/ATC CONTRACTOR

- A. The BMS/ATC Contractor shall have a local office within a 50 mile radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency maintenance service on all system components. The BMS/ATC Contractor shall have a 3 year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall be prepared to provide evidence of this history prior to Contract Award should the Commissioner request it.
- B. The BMS/ATC Contractor shall be prepared to make a personal presentation of his systems to the Commissioner prior to award of Contract should the Commissioner request it.
- C. The engineering, installation, calibration, hardware, software programming and checkout necessary for complete and fully operational BMS/ATC systems, shall be provided under this division by the BMS/ATC Installer.
- D. Control components shall be mounted and wired by the BAS/ATC Contractor except as noted. Controllers may be mounted on terminal units at the factory.

1.11 SUBMITTALS AFTER CONTRACT AWARD

- A. The following data/information shall be submitted for approval:
 - 1. Complete sequence of operation.
 - 2. Control system CAD generated drawings including all pertinent data to provide a functional operating system.
 - 3. Valve, and damper schedules showing size, configuration, capacity and location of all equipment.
 - 4. Data sheets for all hardware and software control components.
 - 5. A description of the installation materials including conduit, wire, flex, etc.
 - 6. Building Management System panel locations.
 - 7. Schematic and flow diagrams indicating sensor and device locations.
- B. The Controls Contractor shall provide submittal drawings for the entire control system for review and approval before work shall begin. Included in the submittal drawings shall be a diagram depicting the system architecture complete with a communications riser. Drawings shall include point-to-point wiring diagrams and must show all temperature controls, start-stop arrangement for each piece of equipment, equipment interlocks, wiring terminal numbers and any special connection information required for properly controlling the mechanical equipment. The submittal shall include a bill of material reference list as well as equipment sequences of operation.

- C. The submittals shall include a specification compliance analysis for review and approval before work shall begin. The compliance document shall address each paragraph of this specification by indicating COMPLY, EXCEED, or EXCEPTION. Do not indicate COMPLY unless the proposed system exactly meets the paragraph requirement. If EXCEED or EXCEPTION is indicated, then provide a clear and concise explanation of the variance from the specifications and the net effect this would have on the specified system performance.
- D. Wiring diagrams shall include internal wiring of all electrical control devices.
- E. Submit completed computer graphics for all the equipment and building floor plans minimum floors prior to scheduled completion of the project for approval.

PART 2 – PRODUCTS

2.1 GENERAL

- A. The Building Management System (BMS) shall provide an easy to use interface for monitoring and managing the building. The Building Management System shall provide the necessary Hardware, Software, and Network Communication abilities to provide Scheduling, Monitoring, Trending, Historical Storage, and Alarm Functions for the HVAC equipment and systems as described in this specification. Control capabilities shall include: Time of Day scheduling, Direct Digital Control, Custom Control, Boolean Logic, Optimum Start/Stop, Duty Cycling, Electrical Demand Control, Temperature Control, After Hours Override, Reports and Logs, Trend Prints, Remote Communications, Alarm Logging, Run Time and Maintenance, and Expanded Informational Messages.
- B. The Building Management system shall be designed to allow full Operator operation with a minimum of training. It shall have an on-screen "Help" Operator tutorial.
- C. Specified application programs shall be engineered, programmed and pre-tested prior to site installation. This shall be verified by standard format programming worksheets or flow diagrams included with the submittals.

2.2 BUILDING MANAGEMENT SYSTEM

- A. Each panel memory shall be protected for a minimum of 48 hours in the event of power failure. Internal clock shall continue to run during a power failure so that the system makes the appropriate adjustment to all connected points when power is restored.
- B. When specified or indicated on the point list or where required by the sequence of operation, outputs shall have three position manual override switch (On/Off/Auto), a status light, and shall be selectable for either normally open or closed operation.

2.3 MANUFACTURERS

- A. Acceptable Manufacturers Are:
 1. Andover Controls
 2. Johnson Controls as installed by local factory office.
 3. Landis Staefa as installed by local factory office.
 4. Siemens Controls as installed by local factory office.
 5. Trane as installed by local factory office.

Any other manufacturer shall be considered a substitution and may submit for approval

after the bid.

2.4 SYSTEM PERFORMANCE

- A. The system shall consist of Operator Workstation, Building Management Panels, and Application Specific Controllers. All elements of the system shall be designed for standalone operation. Control shall always occur at the lowest level of the system. Communication between the building management panels and workstations shall be over a high speed communications buss. All nodes on this LAN shall be peers. The operator shall not have to know the panel identifier or location to view or control an object. Application Specific Controllers shall be constantly scanned by the building management panels to update point information and alarm information.

2.5 APPLICATION SPECIFIC CONTROLLERS

- A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient EEPROM memory to handle its operating system, database and programming requirements.

The controllers shall be clearly labeled as to controller type, where it is to be installed, and software address (if applicable). The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

- B. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.
- C. The hardware shall be suitable for the anticipated ambient conditions.
 1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40°F to 155°F.
 2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

2.6 CUSTOM APPLICATION CONTROLLERS

- A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient EEPROM memory to support its operation system, database, and programming requirements. Custom application controllers shall meet the requirements of 2.06 Master Control Panels except they shall reside on a communications network operating at a minimum of 38,400 KBPS.
- B. All programming required for operation shall be memory resident and shall be retained in permanent memory.
- C. The Custom Application Controller shall be configured such that the Portable Operators Terminal can be plugged directly into it or within sight for programming, editing, and other operator functions.
- D. Controller hardware shall be suitable for the anticipated ambient conditions.
- E. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures and shall be rated for operation at -40°F to 155°F.
- F. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32°F to 120°F.

2.7 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through Master Control Panel, Custom Application, or Application Specific Controllers. Any critical points requiring immediate reaction shall be tied directly in to the controller hosting the control software algorithm for the critical function.
- B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a sufficient wetting current to be compatible with commonly available control devices.

All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.

- C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices. Where specified in the sequence of operations or indicated on the points list, binary outputs shall have 3-position (on/off/auto) override switches, status lights, and shall be selectable for either normally open or normally closed position.
- E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 0 to 20 VDC or a 4 to 20 milliampere signal as required to provide proper control of the output device. Systems that utilize a pulse width modulating output (PWM) shall include a position feedback AI for each output.
- F. System architecture shall allow for point expansion in one of the following ways:
 - 1. The addition of input/output cards to an existing System Application Controller.
 - 2. An additional panel and/or controller may be used to expand point capacity.
 - 3. Ten (10) percent expansion capacity for all point typed in all DDC panels.

2.8 IDENTIFICATION

- A. Engraved Labels
 - 1. Material: Melamine plastic laminate.
 - 2. Thickness: 1/16".
 - 3. Color
 - a. Surface: White.
 - b. Core: Black (letter color).
 - 4. Fastenings: Any of the following:
 - a. Screws.
 - b. Rivets.
 - c. Permanent adhesive.
 - 5. Lettering: Coordinate with shop drawings.

2.9 DUCT SMOKE DETECTORS

- A. Duct smoke detectors shall be provided and wired in accordance with manufacturer's requirements.

2.10 PIPING

- A. Exposed Air Piping: Hard copper tubing or flame-resistant plenum rated polyethylene tubing in metal conduit or trough.
- B. Concealed Air Piping:
 - 1. Soft copper tubing, or flame-resistant plenum rated polyethylene tubing, properly supported.
 - 2. Do not use polyethylene tubing near sources of heat.

2.11 BMS/ATC CONTROL WIRING

- A. General: 18 AWG Twisted pair cable shield wire shall be provided if required by system manufacturer.
- B. Provide for all input and all analog output wiring.
- C. Tinned copper conductors.
- D. Do not run input/output wires together in the same conduit or wire bundle with 120V power wiring.
- E. Pneumatic or sensor tubing shall not be installed in conduit with any wiring conductors.
- F. All control wiring shall be run in metal conduit complying with Division 26 requirements.

2.12 DAMPERS

- A. The Building Automation System supplier shall provide all automatic control dampers not specified to be supplied integral to the HVAC equipment.
- B. Dampers shall be low leakage or high velocity low leakage air foil as specified in the sequence of operation or in the equipment specifications and schedules. All proportional dampers shall be opposed blade type, except mixing dampers shall be parallel type. Two position dampers may be opposed or parallel blade type.
- C. Damper frames and blades shall be galvanized steel and a minimum of 16 gauge. Blade width shall not exceed 8 inches. Dampers and seals shall be suitable for temperature ranges of – 50°F to 250°F.
- D. Blades: 14-gauge, or 16-gauge air foil shaped, double, galvanized steel or extruded aluminum.
- E. Bearings: Nylon or oil impregnated.
- F. Axles: Welded, hexagonal or pin lock, or with other approved method to prevent blade rotating on axle.
- G. Hardware: Zinc plated steel or aluminum.
- H. Standard Low Leakage Dampers:
 - 1. Standard low leakage dampers shall be provided to conserve energy. Dampers shall be equipped with neoprene edge seals and compressible metal jamb seals. Leakage shall not exceed 10 CFM/Sq. Ft. at 4" W.G. differential.
 - 2. Standard Low Leakage dampers shall be Ruskin, Model CD36 or equivalent.

2.13 CONTROL VALVES

- A. Provide control valves of the type, body material and pressure class as determined by manufacturer, based on operating requirements and maximum pressure and temperature in the piping system.
- B. Equip control valves with actuators of proper close-off rating.
- C. Modulating control valves shall have equal percentage or linear flow characteristics.
- D. Valve bodies shall be 2-way normally open or closed, or 3-way mixing as specified or as required. Valve bodies 2" and smaller shall be bronze, screwed type and 2½" and larger shall be iron, flanged and rated at 240°F 125 psig except where otherwise noted.
- E. Valves shall have stainless steel stems and allow for servicing including packing, stem, and disk replacement, or offer a 5 year warranty on parts and labor.
- F. Size valves for 50% coil pressure drop (minimum 3', maximum 12' pressure drop).
- G. Two-position, two-way control valves shall have quick opening characteristics.
- H. Three-way valves shown in mixing application shall have a single, double faced disk.
- I. Three-way valves shown in diverting application shall have two separate disks on a common shaft.

2.14 VALVE ACTUATORS: (ELECTRIC)

- A. Valve actuators shall be electronic low voltage (24VAC), and properly selected for the valve body and service. Belimo or equivalent.
- B. Actuators shall be fully proportioning (if modulating) and be spring return for normally open or normally closed operation as called out in the sequence of operations.
- C. Provide a handwheel or manual positioner mounted adjacent to valve to allow manual positioning of valve in the absence of power.
- D. Tri-state floating control non-spring return actuators are acceptable for terminal reheat applications for sizes less than one inch.
- E. Actuators that rely on heating a medium are not acceptable.

2.15 TEMPERATURE SENSORS

- A. Temperature sensors shall be Resistance Temperature Detector (RTD) or Thermistor as dictated by the requirements of this specification.
- B. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 5 feet in length.
- C. Immersion sensors shall be provided with a separable stainless steel or brass well to match pipe material.

- D. Space sensors shall be equipped with setpoint adjustment and/or override switch as specified on the plans or in the sequence of operations. Space sensor shall have a portable service tool jack.
- E. Accuracies shall be $\pm 1^{\circ}\text{F}$ for standard applications. Where high accuracy is required, accuracies shall be $\pm .2^{\circ}\text{F}$.
- F. Duct mounted averaging sensors shall utilize a sensing element incorporated in a copper capillary with a minimum length of 20 feet. The sensor shall be installed according to manufacturers recommendation and looped and fastened at a minimum of every 36 inches.
- G. Sunshields shall be provided for outside air sensors.

2.16 FREEZE PROTECTION DUCTSTATS

- A. An electric freeze protection ductstat with 20 feet low temperature sensing capillary, and with manual reset, shall be located across the entering face of each cooling coil or bank of coils in the air conditioning unit or in the discharge of each heating coil in the heating and ventilating units, which shall on a fall in temperature below 35°F ., shut down its respective supply fan and close the outdoor air damper. Case of instrument shall be located outside of supply unit, within 10 feet of supply fan motor.
- B. For systems with return air fans, on fan shut down, the return fan shall continue running or shall start, if not running.

2.17 PRESSURE SENSORS

- A. Differential air pressure, static pressure and velocity pressure sensors shall be furnished by Modus, Air Monitor or equivalent.
- B. Liquid, water or steam pressure sensing shall be furnished by Rosemount, Robinson Halpern or equivalent.
- C. Pressure switches shall be furnished by United Electric, Dwyer or equivalent.

PART 3 – EXECUTION

3.1 FUNCTION

- A. Provide all components necessary to achieve the Sequences of Operation listed in Part IV and any additional industry standard functions normally required of a first class BMS/ATC installation.
- B. This division shall provide a project manager who shall, as a part of his duties, be responsible for the following activities:
 1. Coordination between this Contractor and all other trades, Commissioner, local authorities and the design team.
 2. Scheduling of manpower, material delivery, equipment installation and checkout.
 3. Maintenance of construction records such as project scheduling, manpower planning, and as-built drawings for project coordination and as-built drawings.

3.2 INSTALLATION METHODS

- A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Electrical sections of these specifications.
- B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.
- C. Control Wiring:
 - 1. Number-code or color-code conductors appropriately for future identification and servicing of control system.
 - 2. All line voltage power wiring required because of substitution of low voltage power wiring equipment specified in this division, shall be provided by this division.
 - 3. Comply with the applicable requirements of Division 26 for the installation of electrical wiring incidental to the temperature control system.
 - 4. Comply with the applicable requirements of National Electrical, New York City Building Code, and Building Code for the installation of electrical wiring incidental to the temperature control system.
 - 5. Control wiring shall be run in conduit in accordance with the electrical sections of this specification.
 - 6. Conduit shall be run parallel to building lines properly supported and sized at a maximum of 40% fill. In no cases shall field installed conduit smaller than 1/2" trade size be allowed. Where conductors are not in conduit, cable rated for use in return air plenums shall be used.
 - 7. BMS/ATC division shall provide all control transformers and all control wiring (including low voltage actuator power wiring). This division shall also provide power wiring from the control circuits to the transformer locations and all other temperature control devices requiring power wiring. Electrical Contractor shall furnish appropriate control circuits (both normal and emergency) in suitable panelboards located throughout the project.
 - 8. BMS/ATC division shall provide UL listed surge protectors for all control circuits upstream of control transformers.
- D. Equipment installed under other divisions of the specifications:
 - 1. Furnish dampers, valves, temperature sensor wells, flow switches and other equipment to Installers at proper time.
 - 2. Provide installation instructions.
- E. Adjust low-leakage dampers so all gaskets and seals are properly compressed.
- F. Provide outside air and relative humidity sensors at each outside air intake louvers for air handlers.
- G. Unless specifically indicated on plans, do not install wall mounted thermostat or temperature sensor on exterior wall. For thermostats or temperature sensors located on an exterior wall, provide insulated base behind device.

3.3 IDENTIFICATION

- A. Devices Inside Panels: Either of the following:
 - 1. Engraved labels.
 - 2. Lettered in permanent ink with felt tip marker.

- B. Exposed Devices: Engraved labels.
- C. Location: On the body of the device or on the surface to which it is mounted.
 1. Do not put identification on removable covers.
- D. Label each remotely mounted control panel as to the device it controls.

3.4 OPERATING AMBIENT CONDITIONS

- A. Electronic controls mounted in unconditioned space shall be rated for ambient operating conditions from -40°F to 155°F. Controls not meeting these limits shall be mounted in an accessible location within conditioned space.

3.5 CALIBRATION AND ADJUSTMENTS

- A. After completion of the installation, perform final calibrations and adjustments of the equipment provided under this contract and supply services incidental to the proper performance of the ATC and BAS system under warranty below.

3.6 OPERATION BY COMMISSIONER

- A. Commissioner may require operation of part of the system prior to final acceptance. Operation is not to be construed as acceptance of work.

3.7 ACCEPTANCE PROCEDURE

- A. General: The system installation shall be complete and tested for proper operation prior to acceptance testing for the Commissioner.
- B. Upon completion of the calibration, Contractor shall startup the system and perform all necessary testing and run diagnostic tests to ensure proper operation. Installer shall be responsible for generating all software and entering all database necessary to perform the sequence of control and specified software routines. An acceptance test in the presence of the Commissioner shall be performed.
 1. If more than two of the first 10 devices tested, or more than 10% of the first 20 or more devices tested, fail to operate properly, the test shall be discontinued.
 2. Additional testing, after corrections are made, shall be done at the Installer's expense.
- C. A letter shall be submitted to the Commissioner requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within ten (10) calendar days of request. When the field test procedures have been demonstrated to the Commissioner, the system will be accepted. The warranty period will start at this time.
- D. Field Equipment Test Procedures: DDC Zone and Local Controllers shall be demonstrated via a functional end-to-end test as follows:
 1. All output channels shall be commanded (on/off, stop/start, adjust, etc.) and their operations verified. (Point -to- Point Checkout)
 2. All analog input channels shall be verified for proper operation.
 3. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
 4. If a point should fail testing, perform necessary repair action and retest failed point and all interlocked points.

5. Automatic control operation shall be verified by introducing an error into the system and observing the proper corrective system response.
6. Selected time and setpoint schedules shall be verified by changing the schedule and observing the correct response on the controlled outputs.

E. Acceptance Test of Mechanical Systems

1. Perform at least two (2) operational tests of the entire mechanical system as described in the specifications.
2. Give each element of the system an operating test of not less than 48 hours' duration to demonstrate to the satisfaction of the Commissioner that the control system is functioning properly and that the system is capable of producing the required environmental conditions. During this test, operate the system entirely on automatic control and take periodic readings of the inside and outside wet and dry bulb temperatures. Obtain wet and dry bulb temperatures with a recording thermometer-hygrometer. Conduct tests with outside temperature and humidity conditions as near design conditions as practical.
3. Winter acceptance test shall be conducted when outside temperatures are at or near 10°F, summer acceptance test shall be conducted when outside temperatures are at or near 90°F db.
4. Conduct tests during summer and winter outdoor temperature extremes as specified above. Notify Commissioner seven (7) days in advance of proposed tests.
5. Record temperature and humidity at an exterior and interior location for each system as designated by the Engineer at least once every hour for 48 hours during tests.
6. Submit a report detailing the following:
 - a. Instrument used:
 - 1) Most recent calibration date.
 - b. Date of tests.
 - c. Description of test apparatus locations and methods.
 - d. Results of tests.
 - e. Any abnormal usage of the building or abnormal system characteristics observed during the course of the test.

3.8 RECORD DOCUMENTS

- A. **Electronic Media As-Built Documentation:** After a successful acceptance demonstration, the Contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply complete 11X17 hard copy as-built drawing sets, together with CD's to the Commissioner. The number of hard copies shall be electronic media equal to the number of O&M manuals (Re: General Conditions and Division 01).
- B. **Operation and Maintenance Manuals:** Submit Operation and Maintenance manuals (Re: General Conditions and Division 01). Include the following in each manual:
 1. BMS/ATC information for insertion into the Manufacturer's catalog data and specifications on all sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in the system.
 2. An Operator's Manual which will include detailed instructions for all operations of the system.
 3. An Operator's Reference Table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.
 4. A Programmer's Manual which will include all information necessary to perform programming functions.
 5. A language manual which will include a detailed description of the language used and all routines used by the system.
 6. Flow charts of the control software programs utilized in the Temperature Control System.
 7. Flow charts of the custom software programs utilized in the Temperature Control System.

8. Complete program listing file and parameter listing file for all programs.
9. A copy of the warranty.
10. Operating and maintenance cautions and instructions.
11. Recommended spare parts list.
12. Twenty-four (24) hour service phone number and point of contact.

3.9 WARRANTY

- A. All BAS/ATC devices and installation shall be warranted to be free from defects in workmanship and material for a period of one year from the date of job acceptance by the Commissioner. Any equipment, software, or labor found to be defective during this period shall be repaired or replaced without expense to the City of New York. Factory authorized warranty service shall be available within 50 miles of jobsite.

3.10 INSPECTION

- A. Examine location where controls and equipment are to be installed and determine space conditions and notify Commissioner in writing of conditions detrimental to proper and timely completion of the work.
 1. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.11 INSTALLATION

- A. Install in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment comply with requirements and serve intended purposes.
- B. Coordinate with the work as necessary to interface installation of equipment with other components of systems.

3.12 FIELD QUALITY CONTROL

- A. Upon completion of installation of the automatic temperature control system and after motors have been energized with normal power source, test system to demonstrate compliance with requirement. When possible, field correct malfunctioning controls then retest to demonstrate compliance. Replace controls which cannot be satisfactorily corrected. Refer to Testing and Balancing Section of this specification.

3.13 SERVICE

- A. After completion of the control system installation, the control manufacturer shall regulate and adjust all temperature sensors, control valves, damper motors, etc., and place in complete operating condition, subject to the approval of the Commissioner. The control contractor shall provide two complete instruction manuals, in addition to any other manuals called for in this specification, to the Commissioner's operating personnel. The manual shall include the function and operation of all control components on this project. Complete instructions shall be given to the operating personnel. There shall be two day's instruction given for Winter cycle and two day's instruction for Summer cycle operation.

PART4 – SEQUENCE OF OPERATION**4.1 GENERAL**

- A. BMS/ATC Contractor shall design, install, program, test, commission and demonstrate a complete and fully functional system capable of meeting the Sequences of Operation detailed below. Provide additional control points and functions as required, even if not specifically called for, if normally considered necessary for a BMS/ATC installation of the size and complexity of this project or if required to implement control sequence.
- B. Listed items of equipment shall be individually controlled by standalone controller. Each controller shall serve only one individual unit. The unit controller shall be supplied by the BMS Contractor and may be furnished to the equipment supplier for factory mounting. The cost to mount, calibrate, program and test the controller and actuator shall be coordinated prior to bid day and included in the BMS price.
 - 1. Perimeter Heat.
 - 2. Fancoil Unit.
 - 3. Rooftop Units.
 - 4. Exhaust fans.
- C. Multiple units may be controlled by individual standalone controllers for all other control points.
- D. Sensor and transducer installation, control power and wiring and communications wiring shall be provided under this division by BMS/ATC Contractor.
- E. Refer to the Systems Points List at the end of this division and equipment schedules on the drawings for required control inputs and outputs for each item of equipment listed in the Sequence of Operation.

4.2 OCCUPANCY SCHEDULES

- A. The following special occupancy schedule types are here-by defined:
 - 1. Office Occupancy: Based on a normal office occupancy (including holidays and weekend scheduling, etc.).
 - 2. Unoccupied.
- B. Any device utilizing on/off control or scheduling shall be capable of being programmed to conform to any of these schedules.

4.3 DEFINITIONS

- A. Primary or Production: Part of the circulation loop which directly flows through a chiller.
- B. Secondary or Distribution: Part of the circulation loop which directly flows through terminal units.

4.4 FIRST FLOOR BLOWER COIL UNIT (AC-1)

Refer to Division 23 34 00 for Fan Coil Units requirements.

A. General

Each blower-coil unit shall have a microprocessor based terminal unit controller (TUC) which shall monitor and control the blower-coil unit in a standalone mode or as directed by the building automation system.

The blower-coil air conditioner shall consist of:

1. Main steam heating coil with a control valve
2. Air supply fan
3. Air filter
4. Return air damper
5. Outside air damper
6. Condensing unit

B. Fan shall start and stop based on programmable 24/7 schedule.

C. In cooling mode the condensing unit shall cycle to maintain space temperature setpoint.

D. In heating mode the steam heating coil shall modulate to maintain room temperature setpoint.

E. Economizer Control:

1. When unit is operating the O.A. damper and return air damper shall be set to maintain minimum outdoor air to the occupied spaces. When the Outside Air Temperature is less than 65°F (adj.), and Cooling is required, the Economizer control shall be enabled to provide cooling to the space without compressor operation. The Outside Air Dampers shall modulate between the adjustable minimum position and full open to maintain the Discharge Air Temperature (55°F, adj.) at the Economizer Setpoint (55°F, adj.). Heating shall be locked out until Outside Air Damper has returned to the minimum ventilation position. When Outside Air Temperature exceeds 65°F or is below 50°F, economizer control shall be disabled and outside air dampers shall return to minimum position. When carbon dioxide levels rise above 500 PPM (adjustable) the O.A. damper shall modulate open, the return air damper shall modulate closed, and the relief air damper shall modulate full open to reduce carbon dioxide concentration when unit heating and cooling capacity permits.

F. When unit is in unoccupied mode the fan shall be off, the O.A. damper shall be closed and the return air damper shall be open. Unit shall cycle on as required to maintain space temperature at 55 degrees during periods where O.A. temperature is less than 45 degrees F.

4.5 ROOFTOP UNIT

A. If communication with the BAS is lost, the air handler controllers shall use their default setpoints and operate in the Occupied mode.

B. Occupied Mode:

1. When the rooftop unit is in the Occupied Mode, the Supply Fan shall operate continuously.

C. Unoccupied Mode:

1. When the rooftop unit is in the Unoccupied Mode, the Supply Fan shall be OFF. The Outside Air Damper shall be closed.

D. Night Setback Mode:

1. Supply fan cycles to maintain set-back space temperature setpoint (offs) or lowest associated zone T-stat.
2. Outside air damper to be closed.
3. Maintain a 6°F (adj.) offset to setpoint:
 - a. Energize heat fully and energize fan at offset. Run until setpoint is reached, then de-energize fan and electric heat.

E. Morning Warm-Up Mode:

1. Supply fan shall run continuously and be energized one hour (adj.) prior to scheduled occupied mode start. Energize heating to warm-up occupied space to occupied setpoint of all associated space stats.
2. O.A. dampers shall be closed.
3. Cooling shall be locked out.
4. Energize heat fully until setpoint(s) are satisfied, maintain a 95°F (adj.) discharge air temperature.
5. Revert to occupied mode when all space stats have reached occupied heating setpoint.

F. Fan Safety Controls:

1. De-energize the Supply Fans whenever the Stop/Auto interlock is open, the Discharge Air Low Limit is tripped, the fire or smoke stat has tripped, or the Supply Fan Status indicates a failure (after a two minute delay). The Fire-stat, Low Limit and the Fan Failures require a manual reset.
2. Alarm the BMS with an appropriate alarm message.

G. Discharge Air Temperature:

1. Provide a "cascade" type reset (via a PID loop) of discharge air temperature (D.A.T.) to maintain space temperature.
2. Space humidity sensor shall override reset control and maintain humidity with highest possible D.A.T.
3. If D.A.T. drops below 40°F (adj.), de-energize all fans and close the outside air damper.

H. Cooling Control:

1. The compressors shall cycle to maintain the Discharge Air Temperature at the Discharge Cooling Setpoint (55 F, adj.). The compressor shall be off if the rooftop unit is in the Heating mode, the Fans are OFF, or the Discharge Air Sensors have failed.

4.6 CABINET UNIT HEATER (STEAM WITH SINGLE PHASE MOTOR)

- A. Steam control valve shall open/close to maintain space temperature setpoint.

4.7 EXHAUST FAN CONTROL

- A. When the exhaust fan is started, a normally closed damper in the fan outlet shall open. When the fan is stopped, the damper shall close.
- B. For dampers furnished by the fan manufacturer, fan manufacturer shall provide electric, totally enclosed, spring return damper motors and dampers, and control manufacturer shall wire to load side of local disconnect switch.

4.8 DIRECT RADIATION

- A. Provide room temperature sensor where shown on Drawings, to control a steam control valve on the steam supply line to each radiator, to maintain 72°F.

4.9 BOILER ROOM FRESH AIR INTAKE

- A. When either burner starts, the fresh air intake damper shall open. When the burners and generators are off, the damper shall close.
- B. Provide an open-auto selector switch on the boiler control panel to override the above operation.
- C. Provide end switch at each combustion air damper to prevent burner from starting until after damper opens.

4.10 DDC SYSTEM POINTS LIST

- A. General: Provide individual inputs or output for each point listed in the points list. Provide any additional points not listed in the points list, but required to meet the sequences of operation, at no additional cost to the City of New York. All analog outputs shall be 4-20mA, 0-10VDC, or 0-20VDC unless otherwise indicated. AO = Analog Output; AI = Analog Input; DO = Digital (binary) Output; DI = Digital (binary) Input.

4.11 MISCELLANEOUS DDC CONTROL

- A. See the points list for additional required alarm and status points which shall be monitored by the BMS.
- B. Reference mechanical equipment schedules (especially "fans") for additional control sequences.

4.12 MISCELLANEOUS NON-DDC CONTROL

- A. Chemical Treatment: Provide required field wiring interlocks.

END OF SECTION

SECTION 23 22 13

STEAM AND CONDENSATE PIPING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit manufacturer's data for the following:

1. Steam traps
2. Strainers
3. Safety valves
4. Pressure reducing valves
5. Vacuum breakers
6. Blowdown separator

PART 2 - PRODUCTS

2.1 PIPING

A. Provide products complying with ANSI B31.1 for Power Piping.

B. Low-Pressure Steam Piping Up to 15 psig:

1. Size 2" and Smaller Pipe:
 - a. Black steel pipe, Schedule 40.
 - b. Fittings: Class 125 cast iron threaded.
 - c. 2" & below C.I., 125# Screwed
2. Size 2-1/2" and Larger Pipe:
 - a. Black steel pipe, Schedule 40.
 - b. Fittings: Class 125 cast iron, flanged, or wrought steel butt welding, extra heavy with steel flanges Class 150.
 - c. 2-1/2" & above: Steel Sch. 40 Welding

C. Low-Pressure Condensate Piping Up to 15 psig:

1. Size 2" and Smaller Pipe:
 - a. Black steel pipe, Schedule 80.
 - b. Fittings: Class 125 cast iron threaded.
 - c. Low Pressure Condensate: Brass, Standard
 - d. Low Pressure Condensate (within 20 feet Of PRV Station): Steel, Schedule

D. Vents (steam safety and relief): 2 1/2" and below: Steel, Schedule 80; 2" and below: C.I., 125#, screwed welding. .

2.2 STEAM TRAPS

A. Manufacturers:

1. Design Basis: Armstrong
2. Other Acceptable Manufacturers:
 - a. AAF

- b. Dunham-Bush
- c. Hoffman
- d. Sarco
- e. Trane

B. Capacity: Continuous flow capacity of twice the maximum equipment condensing rate.

C. Connection Size: ¾ inch, minimum.

D. Access to Internal Parts: Without disturbing piping connections.

E. Valve and Seat: Heat-treated.

- 1. Stainless steel.
- 2. Chrome steel.

F. Float and Thermostatic:

- 1. Model: Series B.
- 2. Body: Cast iron or semi-steel.
- 3. Float: Stainless steel.
- 4. Ratings: SHEMA.

Combination float and thermostatic traps shall have a valve mechanism, the position of which is controlled by a closed, stainless steel ball float. The seat of the valve will be watertight at all times. The action of this type of trap must be gradual and modulating, it must discharge the condensate as soon as it enters the trap and its rate of discharge must be proportionate to the rate of the flow of condensate to the trap.

The traps shall be provided with an automatic, thermostatic air bypass of the balanced pressure, multiple bellows type or disc diaphragm.

All working parts shall be of non-corrosive metal (hard bronze, monel or stainless steel) and shall be removable without disconnecting the piping. Floats shall be of stainless steel.

Body and cover shall be of high grade cast iron suitable for 125 psi pressure for the 0-15 psi line.

0-30 psi traps - all bodies and covers shall be designed for 125 psi steam pressure.

G. Thermostatic:

- 1. Model: Dunham-Bush 1E or 2E.
- 2. Body: Cast brass.
- 3. Thermostatic traps shall be of the corrugated-bellows, balanced pressure type, with a bellows made of high grade red brass or phosphor bronze. Regardless of working pressure traps shall have a minimum working pressure of 125 psi. All steam traps to be sized on condensate at steam temperature.

The bellows shall be either of Phosphor Bronze (with high temperature solder and brass sleeve protection) or Monel metal, properly brazed.

Low pressure (0-15 psi) thermostatic traps shall have castbrass or forged brass bodies suitable for 125 psi pressure and shall be provided with a union connection at the inlet. Self-aligning valve heads and seats for the low pressure traps shall be of a suitable, non-corrosive material. Seats shall be removable.

2.3 STRAINERS

- A. Manufacturers:
 - 1. Design Basis: Armstrong
 - 2. Other Acceptable Manufacturers:
 - a. AAF
 - b. Hoffman
 - c. Mueller
 - d. Sarco
 - e. Trane
- B. Body: Cast Iron or bronze.
- C. Removable Screen:
 - 1. Material: Stainless steel.
 - 2. Net Free Area: Four times pipe area.
 - 3. Perforations:
 - a. Size 2" and Smaller: 1/32 inch.
 - b. Size 2-½" and Larger: 1/16 inch.
- D. Blow-down Valve: Provide valve for strainers 2-½" and larger.
- E. All strainers in steam lines, shall be Y-pattern, set in a horizontal (or vertical downward) run of the pipe. Where this is not feasible, strainers may be of enlarged-cross-section type. Strainers shall be so arranged as not to "trap" pipes, and to facilitate disconnection and opening-up for cleaning. Unless otherwise indicated, strainers shall be line size.
- F. All strainers, 2-1/2" and above, shall have semi-steel bodies of ample strength for the pressure to which they shall be subjected, removable cylindrical or conical screens of monel or stainless steel and suitable flanges or tappings to connect with the piping they serve. They shall be of such a design as to allow blowing out of accumulated dirt, and to facilitate removal and replacement of a strainer screen, without disconnections of the main piping.
- G. Strainer screen perforations shall be 1/32" for steam and mixture of steam and condensate. Strainers of the "Y" type similar to Sarco Bulletin 1220 type IF and AF or approved equal.
- H. All strainers shall be provided with flanged covers for screen removal in lieu of screwed covers wherever obtainable.
- I. All strainer screens 8" and above shall be reinforced for the operating conditions.

2.4 VACUUM BREAKERS

- A. Manufacturers
 - 1. Design Basis: Johnson
 - 2. Other Acceptable Manufacturers:
 - a. Watts
 - b. Durable check valve or approved equal.
- B. Model: VB8-66, VB-75-SS-T, or approved equal.
- C. Size: ¾"
- D. Body: Stainless steel body with threaded outlet connections.

2.5 AIR VENTS

- A. Air valves shall be No. 1A or No. 1B Vari-Vent as may by the Dole Valve Co. or approved equal.
- B. Provide steam air valves on steam mains, returns, and unit heaters. Air vents shall be No. 5 air valve as made by the Dole Valve Co., or approved equal.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Comply with ANSI B31.1 Power Piping Code.
- B. Steam piping shall be welded and x-rayed as per the minimum requirements of ANSI B31.1.

3.1 INSPECTION

- A. Contractor shall examine location where the piping to be installed and determine space conditions and notify Commissioner in writing of conditions detrimental to proper and timely completion of the work.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate with other work as necessary to interface installation of piping with other components of systems.

3.3 STEAM PIPING

- A. All pipe shall be new, free from scale or rust, of the material and weight specified under the various services. Each length of pipe shall be properly marked at the mill for proper identification with name or symbol of manufacturer.
- B. All steel piping, except where otherwise rated, shall be standard or extra strong weight, in conformance with the ASTM A-53 Grade A seamless, for piping 2" and larger, as manufactured by National Tube Division, Republic Steel Corp., or approved equal. Piping shall be ASTM A-53 continuous butt weld, for piping less than 2".
- C. Where possible, install piping with 1.0" minimum drop in 20' pipe run in the direction of steam flow. Otherwise, pitch steam and condensate lines downward one inch per 40 feet in direction of flow to ensure adequate flow and prevent noise and water hammer. Steam and return run outs to risers and to elements shall pitch 1/2 inch per foot. At low points of steam lines provide traps adequately sized to collect condensate. Mains shall be dripped at least every 100 feet of run. All supply mains shall be dripped and trapped on any vertical lift, except where otherwise noted.
- D. Install branch piping with 1.0" minimum drop in 10' pipe run in the direction of flow.
- E. Install branch piping at top of main, either in vertical direction or at 45 degrees from vertical and perpendicular to main. Branches two pipe sizes smaller than main may be installed as horizontal tees.

- F. Provide capped dirt pockets at all traps, riser heels, and wherever dirt and scale may accumulate to meet job conditions, mains shall set up (with drip connections to return line) to maintain headroom, clear other pipes, etc. Steam mains are to be installed as high as possible. System is to be arranged to secure venting of air to the return line at all low points in steam mains, without permitting ingress of air. In any case, where return or drip piping, to meet job conditions, may have to set down under stoops, doors, etc., and again rise after passing these, the sets shall be made up with 45 deg. fittings and with Y-laterals at each end, with brass plugs to permit easy cleaning of trapped portions of pipe. At any points where return mains have to rise again, after being depressed, provide also approved overhead "air lines" (not smaller than 3/4" in size) with adjusting valves, and connect with two high sides. Any turns in water sealed lines shall be made with crosses, with brass plugs in unused outlets to facilitate cleaning. All apparatus subject to high temperature differentials and high steam demand loads such as heating coils and steam-water converters shall have a vacuum breaker.

3.4 CONDENSATE PIPING

- A. Comply with the applicable steam piping installation requirements, except install piping with 1.0" minimum drop in 40' pipe run in the direction of flow.
- B. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Condensate drain piping sizes shall be not less than 1½ ".

3.5 STEAM TRAPS

- A. Except as otherwise indicated, furnish and install steam traps of approved types and capacities for proper venting and draining of all piping and of all pieces of equipment:
1. In the return piping adjacent to each item of equipment utilizing steam.
 2. At the end of each steam main.
 3. At each low point on high pressure system.
 4. Heels of risers
 5. Any other point where condensate and/or air may collect, such as ahead of pressure and temperature regulating valves, lifts and drops in steam mains, etc.
- B. Install with valve and Y-strainer on upstream side of trap.
- C. Install float-and-thermostatic traps on low pressure system.
- D. Install bypass piping around traps on low pressure system.
- E. All traps shall be designed for the steam pressure and service for which they are to be used and shall pass all condensate and air automatically, without passing any steam. Traps shall be of the types as specified hereafter, as may be required for satisfactory operation. All steam traps shall be warranted to have been tested in the manufacturer's plant under steam to insure tight closure and satisfactory operation.
- F. All equipment steam traps shall be sized for a minimum capacity of 300% of the steam loads indicated on the drawings, and at a maximum pressure drop of 1/2 psi for low pressure systems when continuously handling air and condensate.
- G. It shall be this Contractor's responsibility to install the entire system of return line piping so that all condensate will be returned without water hammer.
- H. Each heating unit, regardless of type, shall be installed with shut off valve at inlet. Each radiator or convector shall have at its supply inlet, a bronze body valve of packless quick-opening type which shall pass sufficient steam when fully opened to fully heat the radiator surface with the lowest pressure carried in the mains.

- I. The following schedule of trap types shall apply:

Schedule of Steam Trap Types

Drips for Low Pressure mains and risers.....	FT
Drips for Low Pressure risers under 2 inches.....	FT
Drips for High Pressure mains and risers.....	B
Radiators, convectors, fin-tube radiators.....	T
Airheating, blast coils, preheaters and reheaters.....	FT
Heating equipment requiring temperature control.....	FT
Hot water heaters.....	FT
Tank heater.....	FT
Unit heaters.....	FT
Flash Tank Discharge.....	FT
Heat Exchangers.....	FT
Steam Absorption Refrigeration Machines.....	FT

CODE:

FT - Float and Thermostatic Trap
 B - Inverted Bucket Trap
 T - Thermostatic Trap
 F - Float traps without thermostatic vent

- J. All traps up to and including 2-1/2" size shall be provided with threaded connections. Traps over 2-1/2" size shall be provided with threaded flanged connection.
- K. Traps 2" size or less shall be provided with union connections.

3.6 COMBINATION FLOAT AND THERMOSTATIC STEAM TRAPS

- A. A gate valve and strainer shall be installed ahead of all float and thermostatic traps.
- B. The general arrangement (for 0-75 and 0-125 psig) float and thermostatic traps shall be similar to that of the low pressure float and thermostatic traps with the following exceptions:
1. Valve heads and seats shall be of stainless steel.
 2. Air bypasses must be built to the standard of high pressure thermostatic traps, i.e., corrugated phosphor bronze bellows, high temperature solder and stainless steels head and seat.

Body and cover shall be designed for 200 psig steam.

- C. General arrangement for high pressure float traps (125-200 psig) shall be as given for medium pressure traps, except that body and covers of semi-steel are designed to withstand 250 psi steam and that exterior air vent is of Thermo-Dynamic type.

3.7 VACUUM BREAKER

- A. Install vacuum breakers at:
1. Steam heating coils
 2. And where shown on drawings

3.8 BYPASS PIPING

- A. Except as otherwise indicated, fabricate and install bypass piping using the same materials and the same plane as connected piping, but one pipe size smaller.
- B. Include globe valve in bypass piping.

3.9 DRIP LEGS

- A. Except as otherwise indicated, fabricate drip legs from 2" pipe.
- B. Install to direct steam vertically downward:
 - 1. Include Tee-fitting in vertical pipe.
 - 2. Install dirt leg pipe at 180 degrees outlet of tee-fitting.
 - 3. Close dirt leg pipe with cap.
 - 4. At 90 degrees outlet of Tee-fitting, connect valve, strainer, trap and second valve.
- C. Provide trap with continuous flow capacity of 1.5 lbs. per hr. of condensate per sq. ft. of surface drained pipe.
- D. Install drip legs:
 - 1. At both ends of steam header.
 - 2. At the low points.
 - 3. At vertical offsets.
 - 4. Elsewhere as indicated.

3.10 SYSTEM CLEANING

- A. Before placing steam piping in service, blow out system with steam to remove foreign material.
- B. Place system in operation and waste condensate for minimum of three hours.

3.11 STRAINERS FOR STEAM AND CONDENSATE

- A. There shall be approved strainers in the inlet connections to each coil, steam trap, and each diaphragm valve, and where else indicated on the drawings. The intention is to protect by strainers, all apparatus of an automatic character, whose proper functioning would be interfered with by dirt on the seat, or by scoring of the seat.
- B. Provide approved valved dirt blow-out connections for each strainer (with the valve located 6" to 1'-0" below strainer, or as directed). The blow-out connection shall terminate with a valve, nipple and cap. Blow off shall be 4 pipe sizes smaller than straight pipe - 3/4" minimum size and shall be suitable for a hose connection with cap.

3.12 TESTING

- A. The steam piping system shall be hydrostatically tested upon completion of the installation at 100 psi.
- B. See additional requirements elsewhere in the specification.

END OF SECTION

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SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL**1.1 QUALITY ASSURANCE**

- A. Installer: A firm with at least 3 years of successful installation experience on projects with refrigerant piping similar to that required for this project.

1.2 REGULATORY/REQUIREMENTS

- A. Comply with applicable requirements of the Clean Air Act and City and local Regulations concerning handling of refrigerants.

PART 2 - PRODUCTS**2.1 REFRIGERANT PIPING**

- A. Type ACR copper tube with wrought copper fittings, Type K (hard), 300#, Silver Solder.
- B. End Caps:
 - 1. Provide factory applied plastic end caps on each length of pipe and tube.
 - 2. Maintain end caps through shipping, storage and handling as required to prevent pipe end damage and eliminate dirt and moisture from inside of pipe and tube.

2.2 SHUT-OFF VALVES

- A. Manufacturers:
 - 1. Design Basis: Henry
 - 2. Other Acceptable Manufacturers:
 - a. Mueller
 - b. Superior
 - c. Imperial
- B. Size 7/8 Inch and Smaller:
 - 1. Model: Series 600.
 - 2. Type: Pack-less diaphragm.
 - 3. Material: Forged bronze.
 - 4. Flow: Non-directional.
 - 5. Servicing: Diaphragm changeable under line pressure.
- C. Size 1-1/8 Inch and Larger:
 - 1. Model: Series 200.
 - 2. Type: Wing cap, back seating.
 - 3. Material: Bronze.

2.3 FLEXIBLE PIPE CONNECTORS

- A. Manufacturers:
 - 1. Design Basis: Mason
 - 2. Other Acceptable Manufacturers:
 - a. Metraflex
 - b. Flexonics
- B. Braided bronze with copper tube ends, compatible with refrigerant type for system
- C. Flexible connector shall be line size or connection size, whichever is larger.

2.4 REFRIGERATION SPECIALTIES

- A. Filter Drier:
 - 1. Conform to ARI Standard 710.
 - 2. Sizes ½" and larger - interchangeable core, full flow.
 - 3. Sizes smaller than ½" - sealed type.
 - 4. Minimum burst pressure - 1500 psig.
 - 5. Refrigerant Filter-Dryer: Refrigerant filter-dryers shall be replaceable core "Catch All" type, as manufactured by Sporlan Valve Company.
- B. Sight Glass:
 - 1. Double port moisture indicating, reversible color indicator.
 - 2. Removable sight glass and moisture indicating element.
 - 3. Furnish with a protective cover.
- C. Expansion Valve:
 - 1. Thermostatic type, diaphragm or bellows operated.
 - 2. External superheat adjustment factory set for 10°F superheat (adjustable).
 - 3. Compatible with refrigerant type for the project.
 - 4. Pressure rated per project requirements.
 - 5. Power elements and valve size shall be as recommended by the manufacturer, for the service intended.
 - 6. Thermal expansion valves shall be Type "MVE-G", as manufactured by Sporlan Valve Company, or approved equal, with external equalizer and remote bulb with refrigerant 22 charge.
- D. Solenoid Valve:
 - 1. Provide solenoid valve for systems 25 tons and larger.
 - 2. Compatible with refrigerant type for the project.
 - 3. Valve shall fail in closed position (power open).
 - 4. Valves to have stainless steel diaphragm-welded and lead-proof construction, replaceable thermostatic element and tight seating. Valve shall be as manufactured by Sporlan Valve Company or approved equal.
- E. Moisture and Liquid Indicator: Provide combination liquid and moisture indicators type "See All", as manufactured by Sporlan Valve Company.

- F. Refrigerant Strainers: Provide Refrigerant Strainers. Strainers shall be as manufactured by Henry Valve Company, Type 895.

1. Acceptable Manufacturers:

- a. Alco
- b. Sporlen

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Run piping level or plumb, except slope gas piping to compressor with a minimum number of elbows.
- B. Provide oil traps at bottom of suction risers. Size risers for proper oil return.
- C. Size lines for total pressure drop not to exceed 2°F saturation temperature.
- D. Provide necessary flexibility for vibration and expansion with offsets and loops, not expansion joints.
- E. Provide flexible connectors at all unit connections.
- F. Replace air in pipe with dry nitrogen to prevent corrosion during soldering.
- G. Install valves, sight glasses, filter-driers, and accessories, furnished by equipment supplier, but not factory installed.
- H. Insulate all underground refrigerant lines with ½" flexible foam. Use unslit covering and carefully cement all joints.

3.2 HANGERS

- A. For insulated piping, provide hangers of size to fit outside insulation.
- B. For non-insulated piping, provide hangers with elastomer insert to prevent damage to piping from vibration.

3.3 TESTING AND DEHYDRATION

- A. Refrigeration piping shall be tested in accordance with the recommendation of the refrigeration equipment manufacturer and in the following sequence for a period of 24 hours:
 - High Side – Nitrogen at 300 psi
 - Low Side – Nitrogen at 150 psi
 - Entire System – Refrigerant at 5 psi
- B. No visible leaks, losses in pressure or increase in vacuum shall occur during test period.
- C. Use the following procedure to test and hydrate the systems:
 - 1. Isolate any elements which would be damaged by test pressures.
 - 2. Test system with trace gas using an appropriate leak detector.
 - 3. Repair or replace leaking elements of system and re-test.

4. After system has been proven to be free of leaks, evacuate it with a high efficiency vacuum pump to 2.5 mm of mercury absolute, to blow off the pressure in the system to atmosphere and provide final evacuation. Use a Zimmerli gauge to read vacuum. Remove all moisture from the system. Operate the vacuum pump until a vacuum of 2.5 mm Hg. is achieved.
5. Allow the system to stand under vacuum for 24 hours.
 - a. Then, if a vacuum of 2.5 mm can be drawn within 30 minutes, the system shall be considered dry.
 - b. If not, the procedure shall be repeated. Break the vacuum with oil pumped, dry nitrogen, open the compressor suction and discharge service valves and re-evacuate the system to 2.5 mm Hg. absolute. If no noticeable rise in pressure has taken place after 24 hours, the system shall be charged.
6. Break the final vacuum by charging with the correct refrigerant.

END OF SECTION

SECTION 23 31 13**DUCTWORK****PART 1 - GENERAL****1.1 INDUSTRY STANDARDS**

- A. Fabrication and installation shall be by a single firm specializing and experience in metal ductwork for not less than 3 years.
- B. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors National Association) recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.
- C. Comply with American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), except as otherwise indicated.
- D. Compliance to SMACNA and ASHRAE is a minimum requirement. In case of disagreement between sheet metal work described in this Section and SMACNA or ASHRAE, the specification shall govern, unless the requirements of SMACNA or ASHRAE are of greater value.
- E. Comply with SMACNA "HVAC Air Duct Leakage Test Manual" for testing of duct systems.

1.2 SUBMITTALS

- A. Shop Drawings: Submit shop drawings for:
 - 1. Transition elbows.
 - 2. Seal and reinforcing schedule for all ductwork fabrication types.
 - 3. Turning vane and turning vane installation.
- B. Product Data: Submit manufacturer's product data on the following:
 - 1. Duct lining.
 - 2. Duct lining adhesive.

1.3 PRODUCT HANDLING

- A. Protect shop fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Protect ends of ductwork and prevent dirt and moisture from entering ducts and fittings.
- B. Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclosed with waterproof wrapping.

PART 2 - PRODUCTS**2.1 GENERAL REQUIREMENTS FOR DUCTWORK**

- A. Furnish and install the size, connections and run of ducts as indicated on the Drawings. All dimensions represent inside clear dimensions.
- B. While the drawings shall be adhered to as closely as possible, the Commissioner's right is reserved to vary the run and size of ducts during the progress of the work if required to meet

structural conditions.

- C. Install all ductwork in strict adherence to the ceiling height indicated on the Architect's Drawings. Consult with the Electric and Plumbing Contractors, and in conjunction with the above Contractors, establish the necessary space requirements for each trade.
- D. The sheet metal ductwork shall, whether indicated or not, rise and/or drop and/or change in shape to clear any and all conduits, lighting fixtures, plumbing and heating mains to maintain the desired ceiling heights.
- E. The ductwork shall be continuous, with airtight joints and seams presenting a smooth surface on the inside and neatly finished on the outside. Ducts shall be constructed with curves shown on the Drawings, the inside radius of all curves and bends shall be not less than width of ducts in plane of bend.
- F. Provide 12" x 12" access doors for every 50'-0" run of supply and return air duct and at the base of each vertical riser for cleaning purpose.
- G. All air ducts exposed to the weather and not insulated shall be constructed of aluminum and shall be properly braced and supported and secured to the building construction. All seams shall be sealed with 3M Scotch-Seal 800 sealer.
 - 1. The construction of ductwork shall be same as conventional ductwork except where transverse reinforcing angles not required, provide 1" x 1" x 1/8" black iron bracing angles matched angles at joint and 1" x 1" x 1/8" black iron between joints 4'-0" from joints.
 - 2. Provide 1/8" thick gasket (3M EC-1202 or equal) for all matched angles.
 - 3. Edge of ducts shall be bent 1/2" over matched angles to obtain watertight seal.
 - 4. Rivet angles to duct and seal with 3M Scotch-Seal 800 sealer.
 - 5. Paint black iron angles after installation.

2.2 DUCT PENETRATIONS THRU FLOOR

- A. Provide 4" high and 4" wide concrete pad all around opening at duct penetrations thru floors. Fill in space between duct and floor construction with mineral wool.

2.3 DRAIN PANS

- A. Provide aluminum pans and gutters under all equipment subject to leaks mounted above electrical equipment. Each copper pan shall be properly pitched and a drain outlet provided and piped to drain. See "Drip Pans".
- B. Provide insulation under drain pans for cooling coils consisting of 2" thick rigid insulation.

2.4 DUCTWORK MATERIALS

- A. All interior ducts shall be constructed with G-90 or better galvanized steel (ASTM A653/653M) LFQ, chem treat. Exterior ductwork or duct exposed to high humidity conditions (i.e. kitchen exhausts) shall also be G-90 or better galvanized steel LFP, chem treat.

2.5 RECTANGULAR DUCT

- A. Construct rectangular ductwork in accordance with Section II and to meet all functional criteria defined in Section VII, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 1995 Edition. All ductwork must comply with all local, state and federal code requirements.

- B. All rectangular ductwork, unless otherwise noted, shall be built from galvanized sheet steel and thoroughly braced and stiffened
- C. Where the standard allows the choice of external reinforcing or internal tie rods, only the external reinforcing options shall be used.
- D. Pittsburgh lock shall be used on all longitudinal seams. All longitudinal seams will be sealed with mastic sealant. Snaplock is not acceptable.
- E. Ductmate or W.D.C.I. proprietary duct connection systems will be accepted. Duct constructed using these systems will refer to the manufacturers guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcements.
- F. Formed on flanges (T.D.C./T.D.F./T-25A/T-25B) shall be constructed as SMACNA T-25 flanges, whose limits are defined on Page 1.36 1995 SMACNA Manual, First Edition. No other construction pertaining to formed on flanges, will be accepted. Formed on flanges shall be accepted for use on ductwork 42" wide or less, 2" static (positive) or less and must include the use of corners, bolts and cleat.
- G. Ductmate type systems that use a butyl Rubber Gasket which meets Mil-C 18969B, Type II Class B, TT-C-1796 A, Type II Class B, and TTS-S-001657 must also pass UL-723. This material, in addition to the above, shall not contain vegetable oils, fish oils, or any other type vehicle that will support fungal and/or bacterial growth (as defined in 21CFR 177, 1210 closures with sealing gaskets for food containers).
- H. Aluminum duct shall be fabricated using the aluminum thickness equivalence table in the standard. Simply increasing the thickness by two gauges is not acceptable.
- I. Fittings shall be constructed and reinforced as ductwork according to the longest span.
- J. For duct construction pressure 2" w.g. or below:
 - 1. Flat areas of duct over 18 in. wide shall be stiffened by cross breaking or beading.
 - 2. All joints to have corner closures.
 - 3. All joints shall be sealed with 3M Scotch-Seal 800 mastic.
- K. For duct construction pressure 2-5" w.g.
 - 1. All seams on fitting shall be continuously welded. If the zinc coating is burned off the steel during welding, apply zinc chromate paint to prevent corrosion.
 - 2. Companion angles shall be bolted to each other with 1/4 in. x 3/4 in. stove bolts, spaced not more than 6 inches apart.
 - 3. Hangers shall be as described for conventional ducts, except that they shall be fastened to the reinforcing angles, or angle connections. Where this is not feasible cradle hangers with a bottom angle shall be used; angle shall be suspended by angles or rods. Piercing of ducts by hangers, pipes, fasteners, etc., will not be permitted.

2.6 ROUND AND OVAL DUCT

- A. Round and oval duct shall be galvanized steel, constructed in accordance with Section III of the 1995 SMACNA "Duct Construction Standards, Metal and Flexible", except as noted.

1. Lighter gauge factory made duct with an Intermediate standing rod may be used. Submit product data sustaining the equivalency of such duct into SMACNA standard duct.
- B. Round ductwork shall be spiral lock seam construction only. Longitudinal seam duct is not acceptable. Gauges shall be in accordance with SMACNA Duct Construction Standard and fittings in accordance with SMACNA Duct Construction Standard, except as noted:
1. Joints 0"-20" diameter, interior slip coupling beaded at center, fastened to duct with sealing compound applied continuously around joint before assembling and after fastening. Wrap joints with 3-inch wide duct tape.
 2. Joints 21"-72" diameter, use 3 piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Example: Ductmate Spiralmate or equal.
 3. Joints 73" diameter and up, use companion angle flanged joints only as defined on page 3-6 of the SMACNA Manual. Refer to manual for proper sizing and construction details. Ductwall to be welded longitudinal seams.
- C. Fittings shall be continuously welded, standing seam, or spot welded and sealed. Metal thickness and reinforcing shall be equivalent to the requirements of the largest span.
1. All elbows greater than 45" shall be radius type, $R=1.5$ times duct diameter.
 2. Elbows less than 12" shall be of die stamped construction. Elbows 12" or greater shall be 5-piece construction.
 3. Diverging and converging flow fittings shall be constructed with no excess material projecting from the body into the branch tap entrance. All such fittings shall be 45° "shoe" entrance, wye plus elbow, or 45° lateral branch. Special fittings such as heel tapped elbows and bullhead tees may be used only where shown on drawings. Adjustable elbows and straight saddle taps shall not be used. Low pressure adjustable elbows acceptable.
- D. For duct construction pressure 2" w.g. or below:
1. Ductwork up to 36 in. diameter shall be spiral lockstream construction and it shall be assembled with prefabricated fittings made up of 20 gauge galvanized iron.
 2. All joints shall be sealed tight with Scotch-Seal 800. Joints shall, in addition, be fastened with selftapping screws.
- E. For duct construction pressure 2" w.g. or greater:
1. All seams on fitting shall be continuously welded. If the zinc coating is burned off the steel during welding, apply zinc chromate paint to prevent corrosion.
 2. Companion angles shall be bolted to each other with 1/4 in. x 3/4 in. stove bolts, spaced not more than 6 inches apart.
 3. Hangers shall be as described for conventional ducts, except that they shall be fastened to the reinforcing angles, or angle connections. Where this is not feasible cradle hangers with a bottom angle shall be used; angle shall be suspended by angles or rods. Piercing of ducts by hangers, pipes, fasteners, etc., will not be permitted.

2.7 MISCELLANEOUS DUCTWORK MATERIALS

- A. General: Provide miscellaneous materials and products of the types and sizes indicated, and where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.
- B. Double wall turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct. Tab spacing shall be SMACNA standard. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert tabs, which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs. when fastened per the manufacturers instructions. Approved Systems: Ductmate PRO-Rail.
- C. Single wall splitter and turning vanes shall be custom fabricated as specified below.
- D. Ductwork Support Materials: Except as otherwise indicated, provide galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
- E. Duct Sealant:
 - 1. Manufacturers:
 - a. Design Basis: United McGill
 - b. Other Acceptable Manufacturers:
 - 1) Ductmate Industries, Inc., PROSeal
 - 2) 3M
 - 3) Precision
 - 2. Model:
 - a. Indoor: United Duct Sealer
 - b. Outdoor: Unicast
 - 3. Description: Non-hardening, liquid or mastic elastic sealant.
 - 4. Fire Rating: UL 289U listed and NFC 220(b).
- F. Duct Tape Sealing System:
 - 1. Manufacturers:
 - a. Design Basis: Hardcast.
 - 2. Model:
 - a. Tape: DT
 - b. Indoor Adhesive: FTA-20
 - c. Outdoor Adhesive: RTA-50
- G. Acoustical Duct Lagging:
 - 1. Manufacturers:
 - a. Design Basis: Sound Seal
 - b. Other acceptable manufacturers:
 - 1) Kinetics Noise Control
 - 2) The Proudfoot Company
 - 3) Acoustical Solutions

- c. **Model: B-10 LAG/QFA-3, foil face loaded vinyl or lead barrier sheet fully bonded to a minimum 1" thick fiberglass blanket, nominal density of 1.0psf, install so jacket edges overlap by minimum of 6", minimum STC-27 tested by independent laboratory in accordance with ASTM E90 and E413, minimum insertion loss (IL) value at 500Hz shall be 23 and meets IMC flame/smoke ratings in accordance with ASTM E84.**

H. Fiberglass Ductboard:

1. Fiberglass ductboard is not accepted without prior written approval from the specifier.

I. Access Doors:

1. Wherever necessary in ductwork, casings or sheet metal partitions, provide suitable access doors and frames to permit inspections, operation and maintenance of all valves, coils, humidifiers, controls, smoke dampers, smoke detectors, fire dampers, filters, bearings, traps, or other apparatus concealed behind the sheet metal work. All such doors shall be of double construction of not less than No. 20 gauge sheet metal and shall have sponge rubber gaskets around their entire perimeter. Doors in insulated ducts of insulated casings shall have rigid fiberglass insulation between the metal panels.
2. All access doors in sheet metal ducts shall be hung on heavy flat hinges and shall be secured in the closed position by means of cast zinc clinching type latches. Where space conditions preclude hinges, use four heavy window type latches. Doors into ducts shall in general not be smaller than 18" x 18" except for access door to fire dampers which will depend on size of fire damper.

J. Flexible Duct Connector:

1. Flexible duct connector shall be used where ductwork connects to fans of apparatus, or apparatus casing to fans so as to prohibit the transfer of vibration from fans to ductwork connecting thereto. Connectors will meet NFPA 90A and 90B specifications and provide an airtight and waterproof seal. Indoor installations shall be Neoprene or vinyl coated fabrics. Outdoor installations shall use Hypalon coated fabric. Connector shall be Ductmate PROFlex or approved equal.
2. The flexible connections shall be a minimum of 12" long including bands using extra wide fabric as specified and held in place with heavy metal bands, securely attached, to prevent any leakage at the connection points. The fabric shall have a maximum length of 10".
3. Flexible connections shall be fabricated from an approved flame retardant fabric each having a maximum flame spread index/rating of 25 and a maximum smoke developed ration of 50.

Range hood exhaust Installations shall be Flame-Proof Silvaseal by Duro Dyme or equal.

Low Pressure Systems

- neoprene coated glass fabric
- 30 ounce/sq. yd.

4. Flexible connections shall not be painted.
5. Flexible connections shall be installed between all rigid ductwork or casing and all air handling equipment.

K. Roof Mounted Duct Supports

1. Manufacturers
 - a. Miro Industries, Inc.
 - b. Portable Pipe Hangers, Inc.
 - c. Approved Equivalent.

Description: Duct on roof shall be supported by an engineered prefabricated portable pipe system specifically designed to be installed on the roof without roof penetrations, flashing or damage to the roofing material. The system shall consist of recycled rubber or plastic bases, hot dipped galvanized or stainless steel frame with threaded rods and suitable pipe hangers and supports. The system shall be custom designed to fit the piping and conduits to be installed and the actual conditions of service.

L. Seismic Restraints

Provide seismic restraints as required for seismic zone.

2.8 FABRICATION

- A. Construct rectangular ductwork to meet all functional criteria defined in Section VII, of the SMACNA "HVAC Duct Construction Standards Metal and Flexible" 1995 Edition. This shall be subsequently referred to as the SMACNA Manual. All ductwork must comply with all local, state and federal code requirements.
- B. Ducts shall be neatly finished on the outside with all sharp edges removed.
- C. Inside surfaces shall be smooth with no projections into the air stream except where otherwise indicated.
- D. Transverse joints shall be made airtight with all laps in the directions of air flow.
- E. All fasteners and attachments shall be made of the same material as the ducts.
- F. Furnish test wells 12" on the center horizontally and vertically in the suction and discharge duct of each fan. Test wells shall consist of a 1" x 3/4", 125 lb., bronze, screwed hex bushing, secured to the duct with a bronze hex locknut on the inside of the duct. A 3/4" x 2" long standard weight bronze, screwed nipple and cap shall be fitted to the housing on the outside of the duct. Test wells shall be no. 699 as made by Ventlok or approved equal.
- G. Supply air duct from constant volume air handlers; +2" W.C., -1" W.C., Seal Class A.
- H. Environmental exhaust duct: +2" W.C., -2" W.C., Seal Class B.
- I. Return duct; +2" W.C., -2" W.C., Seal Class A.
- J. Outside air duct; +2" W.C., -2" W.C., Seal Class A.
- K. Supply duct from fan coils, blower coils, similar; +1", Seal Class B.
- L. All low pressure ductwork is to be constructed for 2" W.C., positive and 1" negative static pressure and 2000 FPM.

- M. See air handler and fan schedules for external pressure requirements. All pressures above 2" shall be constructed as medium pressure.
- N. All low pressure ductwork is to be constructed for 2" W.C. positive and 1" negative static pressure and 2000 FPM.
- O. All negative pressure ductwork shall be constructed for 2" W.C. negative and 2" W.C. positive static pressure and 2000 FPM velocity.
- P. Make all changes in direction using 1.5 radius elbows where possible. Use splitter vanes or mitered rectangular elbows with turning vanes otherwise.
 - 1. Use single thickness splitter vanes for all radius elbows less than 1.5
 $D = r$.
 - a. D = diameter of duct or width of duct (in plane of change-in-direction).
 - b. r = radius of duct at duct center-line.
 - c. Use "Curve Ratios" of 0.45 or greater (as defined by figure 3-7 of the 1989 ASHRAE Fundamentals Handbook).
 - 2. Use single thickness turning vanes with no trailing edges in accordance with SMACNA Standards.
 - a. All mitered, rectangular elbows in series.
 - b. All mitered, rectangular elbows less than 36" in width (in plane of change-of-direction).
 - 3. Use double width, airfoil type turning vanes with no trailing edges for all, rectangular elbows greater than 36" in width (in plane of change-of-direction).
 - a. Isolated elbows have a minimum of 3D straight duct upstream and downstream of the change-in-direction.
- Q. Fabricate transition elbows with turning vanes at correct angle so entering and leaving edges are parallel or tangent to air flow.
- R. All square elbows shall have factory-designed and built turning vanes with hollow vanes having different inside and outside curvature, similar to Tuttle and Bailey, Inc., "Ducturns". Shop fabrication vanes will not be approved. Where turning vanes are in conflict with the access doors to fire dampers. They shall be made movable, so that fire dampers shall be accessible.
- S. All branch duct take-offs shall use 45° laterals or 45° "pants-leg" type fittings.
- T. Dissimilar metals shall be connected with flanged joints made up with fiber or neoprene gaskets to prevent contact between dissimilar metals. Flanges shall be fastened with bolts protected by ferrules and washers made of the same materials as the gaskets. Where an aluminum duct is to be connected to a galvanized steel duct, the end of the galvanized steel duct shall be coated with heavy black asphaltum paint before connecting it to the aluminum duct.
- U. Changes in shape and dimension shall conform to the following: Except where otherwise noted, for increases, in cross-sectional area, the shape of the transformation shall not exceed 1" in 7". Except where otherwise noted, for reductions in area, the slope shall not be less than 1" in 4" but 1" in 7" preferred.

- V. Wherever it may be necessary to make provisions for vertical hangers of the ceiling construction passing through ducts, provide streamlined shaped sleeves around such ceiling construction hangers as to fully protect the duct from being punched with holes for the passage of such hangers. Any such streamlined sleeves shall be made air tight at top and bottom of ducts. In no case shall there be more than two rods in any 9 sq. ft. area. No rods shall pierce ducts smaller than 12" in horizontal area.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Contractor shall examine location where ductwork is to be installed and determine space conditions and notify Commissioner in writing of conditions detrimental to proper and timely completion of the work.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF DUCTWORK

- A. Assemble and install ductwork in accordance with recognized industry practices, which will achieve air-tight and noiseless systems, capable of performing each indicated service.
- B. Duct sizes shown on the Drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required.
- C. Install each run with a minimum of joints.
- D. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth.
- E. Support ducts rigidly with suitable ties, braces, hangers and anchors of the type, which will hold ducts true-to-shape to prevent buckling. Supports shall be placed at each joint and change in direction up to a maximum spacing of 8 feet on centers.
- F. Seal ducts in accordance with SMACNA requirements for pressure class indicated.
 - 1. Indoor Ducts: Use liquid or mastic sealant, or tape system.
 - 2. Outdoor Ducts: Use tape system.
 - 3. Approved manufactured joining systems with gaskets may be used in lieu of transverse sealing.
- G. Locate ductwork runs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Casing and hangers shall be installed straight and level and all shall be free of vibration and noise when fans are operating.
- H. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of the building.
 - 1. Limit clearance to 0.5" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
 - 2. Where possible, locate insulated ductwork for 1.0" clearance outside of insulation.

- I. Ducts at ceilings shall be suspended from inserts in concrete slabs except where otherwise indicated. Inserts shall be Grinnel Fig. 279, 282, or 152 as required. Each duct shall be independently supported and shall not be hung from or supported by another duct, pipe, conduit or equipment of any trade. Duct hung below slabs less than 4" thick shall be supported from supplemental steel.
- J. All fastenings to building structure shall be adequate to insure permanent stability of sheet metal work and shall be capable of resisting all applied forces.
- K. Vertical ducts in shafts or passing through floors shall be supported by steel angles or channels, welded, riveted, screwed or bolted to ducts and fastened to building structural members at each floor level. Provide safeing to close all floor openings around ductwork - pack annular space with rockwool and 18 gauge sheet metal safeing. Floor openings in plenums shall have 1/2 inch diameter steel bars constructed in a 6"x6" grid.
- L. Rigid connections between ductwork and non-rotating equipment shall be 12 inch on centers and shall be made with flanged joints, sealed with fireproof material (Fiber or Neoprene gaskets).
- M. In finished spaces, conceal ductwork by locating in mechanical shafts, hollow wall construction or above suspended ceilings.
- N. Where possible, avoid locating ducts on or near floor.
 - 1. Where ducts must be located low, provide metal trestle to protect duct at places where duct will be climbed over.
 - 2. Ducts at floor shall be supported by steel angles suitably anchored to floor construction.
- O. Coordinate the layout with suspended ceiling and lighting layouts and similar finished work as well as other components of systems.
- P. Install access doors where necessary for inspection and maintenance.
 - 1. Provide additional 12" x 12" access door at each low leakage damper.
 - 2. Arrange access doors so that:
 - a. They open against the system air pressure wherever feasible.
 - b. Their latches are operable from either side, except where the duct is too small to be entered.
- Q. Where ducts pass through non-fire-rated interior partitions below ceiling and exterior walls:
 - 1. Conceal the space between the construction opening and the duct or duct-plus-insulation with sheet metal flanges of the same gauge as the duct.
 - 2. Overlap the opening on all sides by at least 1-1½".
- R. Provide volume dampers at all branch take-offs.
- S. Provide conical or tapered taps with balancing dampers on all round ductwork takeoffs.
- T. Where space permits, round or oval ductwork of equivalent diameter may be substituted for unlined rectangular ductwork.

- U. It is the intent to obtain low pressure ductwork construction with minimum leakage. The construction noted in Specifications can produce low or high leakage rates, depending upon the workmanship, particularly with regard to the connection at the top of the ducts. Guarantee that total diffuser volume, measured by means of velometer, shall be at least 95% of actual fan supply (measured by means of a duct traverse tank with a Pitot tube and water manometer). Seal the ductwork at joints with suitable sealers 3M Scotch-Seal 800 and tape. Use of "HARDCAST" or any other material is subject to Commissioner's approval.

3.3 DUCT HANGERS

- A. Low pressure ducts up to 24" on a side or up to 20" diameter shall be suspended with 16 gauge, galvanized strap hangers, 1" wide.
- B. Low pressure ducts 25" to 40" on a side or 21" to 40" diameter shall be suspended with galvanized strap hangers 1" wide by 1/8" thick.
- C. Strap hangers shall be bent 90°, extended down sides of ducts and turned under bottom of ducts a minimum of 2". Strap hangers shall be fastened at ceiling with nuts, bolts and lock washers and to sides and bottom of ducts with sheet metal screws.
- D. All medium and high pressure ductwork and low pressure ducts 41" and larger on a side or diameter shall be suspended with either rod or angle type hangers. No screws shall penetrate medium and high pressure ductwork.
- E. Rod type hangers shall be 3/8" diameter black steel rods threaded at both ends and bottom bracing angles on ducts, with nuts and lock washers.
- F. Angle type hangers shall be extensions of side bracing angles on ducts, bent 90° fastened with nuts, bolts and lock washers.
- G. Hangers for vertical ducts shall be as per SMACNA Duct Manual.
- H. Stainless steel ductwork shall be supported with rod or angle type hangers, so that there will be no penetration of the stainless steel ducts.

3.4 DUCT LEAKAGE TESTING

- A. Installed ductwork shall be tested prior to installation of access doors, take-offs, etc.
- B. All leak testing shall be witnessed by the Engineer or representative of the Engineer. The Contractor shall give the Engineer 72 hours notice prior to testing. Any testing not witnessed by the Engineer or his/her representative, shall be considered invalid and will be redone.
- C. The testing shall be performed as follows:
 1. Perform testing in accordance with HVAC Air Duct Leakage Test Manual.
 2. Use a certified orifice tube for measuring the leakage.
 3. Define section of system to be tested and blank off.
 4. Determine the percentage of the system being tested.
 5. Using the percentage, determine the allowable leakage (cfm) for that section being tested.
 6. Pressurize to 1.5 times operating pressure and repair any significant or audible leaks.
 7. Repressurize and measure leakage.

8. Repeat steps 6 and 7 until the leakage measured is less than the allowable defined in step 5.

NOTE: It is recommended that the first 100'-300' of ductwork installed be tested to insure the quality of the workmanship at an early stage.

- D. All transverse joints and longitudinal seams shall conform to SMACNA's Class A sealing requirements as defined on page 1-6 of the 1995 SMACNA Manual, First Edition.
- E. Constant Volume Systems/Supply Ductwork
Allowable Leakage 1% of design cfm
- F. Constant Volume Systems/Return Ductwork
Allowable Leakage 2% of design cfm

3.5 DUCTWORK STORAGE AND CLEANING

- A. Cleaning:
 1. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris.
 2. Clean external surfaces of foreign substances which might cause corrosion of metal or deterioration of paint.
- B. Protection:
 1. Store duct a minimum of 4" above ground or floor to avoid damage from weather or spills.
 2. Cover all stored ducts to protect from moisture or debris.
 3. Cover all ends of installed ductwork at the end of each workday or when dust and debris producing construction (such as fire proofing, drywall, sanding, or core drilling) is occurring.
 4. Cleaning of new and existing supply ductwork in existing buildings. After completion of ductwork installation clean ductwork as follows:
 - a. Cover all supply registers and diffusers with oil cheese cloth.
 - b. Use supply fan or install temporary fan to provide air to the system for four (4) hours.
 - c. Remove oil cheese cloth.
- C. Ductwork contaminated or damaged above "shop" or "mill" conditions shall be cleaned, repaired or replaced to the Engineer's satisfaction.
 1. Ductliner pre-installed in stored duct which has become wet may be installed if first allowed to completely dry out.
 2. Ductliner in installed ductwork, which has become wet must be completely removed and replaced.
 3. Torn ductliner may be replaced by coating with adhesive if damaged is minor and isolated. Extensively damaged liner shall be replaced back to a straight cut joint.

3.6 ACCESS DOORS

- A. Install access doors where necessary for inspection, adjustment or servicing. In no case shall access to any items of equipment requiring inspection, adjustment, or servicing require the removal of nuts, bolts, screws, wing nuts, wedges, or any other screwed or loose device.

1. Provide additional 12" x 12" access door at each low leakage damper.
 2. arrange access doors so that:
 - a. They open against the system air pressure, wherever feasible.
 - b. Their latches are operable from either side, except where the duct is too small to be entered.
 - c. Install flexible connectors at all duct connections to rotating or reciprocating machinery or equipment.
- B. Each sheet metal chamber shall have access doors for access to all parts of the system. Doors shall be fitted with cast zinc door latches, two per door. Latches shall be operable from both sides of casing. Hinges shall be extra heavy, zinc plated hinges, minimum of two per door. The doors shall be felted or provided with rubber gaskets so as to make them airtight. The doors shall be made with inner and outer shells 2 inches apart so that they may be properly insulated and properly operated. Doors shall be a minimum size of 20" x 48".
- C. Hinges shall be Ventlok No. 150 or 260 with or without screw holes or approved equal. Latch for walk-in access doors shall be No. 260 as made by Ventlok Co. or approved equal. Latch for access door in ductwork shall be Ventlok No. 100 or approved equal.
- D. Where reheat coils are installed in ductwork, provide access doors on downstream and upstream side of coils within 3'-0" of coil.
- E. Access doors at humidifier locations shall be provided on both sides of duct.
- F. Provide access doors at all fire damper locations.

END OF SECTION

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SECTION 23 33 00**DUCTWORK ACCESSORIES****PART 1 - GENERAL****1.1 INDUSTRY STANDARDS**

- A. Comply with SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) latest recommendations for fabrication, construction and details, and installation procedures, except as otherwise indicated.

1.2 SUBMITTALS

- A. Product Data: Submit manufacturer's product data on the following:

- 1. Flexible duct
- 2. Ceiling dampers
- 3. Fire dampers
- 4. Smoke dampers
- 5. Louvers
- 6. Louvered penthouses
- 7. Roof mounted intakes
- 8. Roof mounted reliefs
- 9. Gravity relief dampers
- 10. Sound attenuators

PART 2 - PRODUCTS**2.1 LOUVERS**

- A. Manufacturers:

- 1. Design Basis: American Warming
- 2. Other Acceptable Manufacturers:
 - a. Air Stream
 - b. Arrow
 - c. Dowco
 - d. Greenheck
 - e. J & J Register
 - f. Louvers & Dampers, Inc.
 - g. Pottorff
 - h. Moore
 - i. Ruskin
 - j. United Air
 - k. Wonder Metals

- B. Screens: ½" mesh, .063" aluminum wire.
- C. Blades: Of depth shown by schedule, drainable.

D. Rating Basis:

1. AMCA Standard 500, based on 15 minute test of 48" x 48" louver. Provide louvers with water penetration and pressure drop no greater than specified louver, and with free area no less than specified louver.

2.2 INSULATING AND SOUND REDUCING DUCT LINING FOR LOW PRESSURE DUCTWORK

- A. Furnish and install all soundproofing material specified, indicated or necessary to that all systems will comply with requirement of quiet operation. In general, noise level in any part of building (except in machinery rooms), due to air conditioning or ventilating equipment, ducts, and outlets, shall not exceed 40 decibels at 1200-2400 cycles per second, except as otherwise hereinafter specified.
- B. Furnish and install sound-absorptive lining in ductwork for locations and lengths as indicated and/or hereinafter specified. All soundproofing material, installation and arrangement, shall be as approved. Where ducts are acoustically lined, insulation shall be omitted for extent of acoustic lining. Dimensions noted for lined ducts are inside clear dimensions. Duct sizes shall be increased for liner.
- C. Sound Absorbent Duct Lining for Low Pressure Ductwork - furnish and install as herein specified and/or shown on the drawings (except where otherwise noted) 1" thick, 1-1/2 lb. density, fibrous glass duct lining meeting the requirements of NFPA 90A.
- D. Liner shall be adhered to all interior sides of duct with minimum 100% coverage of fire-retardant adhesive similar to Benjamin Foster⁴ and with weld pins and washers or equivalent mechanical fastening starting 3" from edges and sides, 12" on center all sides. Minimum one row per side for duct size of 12" or less. Mechanical fasteners shall cause quilting of surface. Coated surface shall be toward air stream. Before installing liner, seal all butting edges and final edges with heavy coat of adhesive to seal off air between lining and duct. All exposed edges of lining shall be installed with sheet metal nosing 1-1/2" wide, two gauges heavier than duct. Installation shall be suitable for duct velocities up to 5,000 fpm. Low pressure duct lining shall be provided where specified and/or where shown and noted on the drawings.
- E. Duct sizes indicated on drawings are clear inside dimensions. Increase sheet metal sizes as required to install acoustic lining.
- F. The following ductwork shall be acoustically lined whether or not shown on Drawings.
 1. Ductwork 10' downstream of mixing box and terminal units.
 2. All supply air ductwork within 20' of fan discharge.
 3. All return and exhaust ductwork within 20' of fan intake.
 4. Return air fan and toilet exhaust plenum walls and ceiling, except lining shall be 2 inch thick 4 lb. density, and inner liner of perforated galvanized sheet metal (7/64" dia. holes on 3/16" staggered centers) shall be used.
 5. Outside air duct to air handling units.
 6. All exposed supply, return and exhaust ductwork.

2.3 ACOUSTICAL PERFORMANCE SPECIFICATIONS - GENERAL

- A. It is the intent of this Specification that noise levels due to air conditioning and/or ventilating equipment, ducts, grilles and registers, diffusers and air light fixtures, will permit attaining sound pressure levels in occupied spaces conforming to the following NC curves as explained in the ASHRAE Guide and Data Book.

Office and Conference Rooms	NC-35
Lobby	NC-40
Practice Room	NC-25

- B. Grilles, Registers, Diffusers

1. The maximum permissible sound power levels of air terminal devices when installed and operating per plans and specifications shall be as follows:

Maximum PWL re 10-12 Watts

<u>Octave Band</u>	<u>NC-30</u>	<u>NC-35</u>	<u>NC-40</u>
1	62	64	66
2	52	56	60
3	44	49	54
4	41	46	51
5	38	43	48
6	37	42	47
7	36	41	46
8	37	42	47

- C. Sound Power Levels shall be tested in accordance with ASHRAE Standard 6=36-72.

2.4 BALANCING DAMPERS

- A. At each main branch take-off and in such other locations where required to properly balance the low pressure system, furnish and install volume dampers of the opposed blade, multi-louvered type, which shall be operated by indicating quadrants and set screws, for adjusting the system.
- B. Volume dampers shall be constructed as follows: Damper blades shall not be wider than 12", shall be complete with heavy angle iron frames, connecting and operating links, brass trunnions, and bronze bearings. Dampers, unless otherwise noted, shall be fabricated with not less than No. 16 gauge sheet steel. Blades shall overlap and shall be provided with continuous stops on all four sides of dampers to prevent leakage. Blades shall be galvanized. Blades of dampers shall be set into a flat steel frame with frame securely bolted to the duct. All dampers shall be fitted with a hexagonal brass spindle which shall extend through the exterior of duct and be fitted with an indicating self-locking regulator. Regulator shall be similar to Ventlok 641 or approved equal. All hardware shall be Ventlock or approved equal. For insulated ductwork provide No. 644 self-locking regulator as made by Ventlok or approved equal.
- C. Maximum of two blades without a frame: Over two blades, use a manufactured 16 gauge galvanized stiffened, opposed blade damper in a 14 gauge galvanized steel frame. All hardware shall be galvanized except bronze iolite bearings; Pottorff Model MD-42 or approved equal.

- D. All automatic dampers shall be furnished as a part of the automatic temperature control system by the automatic temperature control manufacturer. Install dampers and provide safeing in ductwork for automatic dampers smaller than duct size.
- E. Movable splitter dampers shall be provided at each and every supply take-off and wherever else indicated. Dampers shall be airfoil, double-wall type. Splitter damper assembly shall be Ventlok 603 Ball Joint Bracket and 600 Blade Bracket or approved equal. All hardware shall be Ventlok or approved equal. Blades to be spot welded or pivoted to shafts. Elevated regulators shall be provided for insulated ductwork.
- F. All dampers shall be made accessible from building construction. Access doors in building structure shall be furnished or provided as herein before specified.
- G. Maximum pressure drop in full open position (@3000 fpm): 0.55
- H. Maximum leakage: 32 cfm/sp at 4" W.C.
- I. Provide cable operated dampers for all balancing dampers located above hard/inaccessible ceilings. Manufactured by Young Regulator or approved equal. Termination options are subject to Commissioner's approval.

2.5 FIRE DAMPERS

- A. Manufacturers:
 - 1. Design Basis: Ruskin
 - 2. Other Acceptable Manufacturers:
 - a. Prefco
 - b. Air Balance
 - c. Safe-Air
 - d. United Air
 - e. United Sheetmetal
 - f. National Controlled Air
 - g. Air Control Products
 - h. Greenheck
- B. Rating: UL555 dynamic 1-½ hours, or 3 hours, UL555S Class II leakage rated. Match construction penetrated.
- C. Size: Metal-to-metal for lined and unlined ducts.
- D. Fusible link only. Use Type B "Top Hat" wherever possible.
- E. Clearly indicate fire damper location on shop drawings. Provide access doors in the ducts and furnish access doors or panels at building construction at each damper of sufficient size and type to permit inspection and replacement of linkage. Assume responsibility to coordinate all locations of duct access doors with the General Contractor to conform with whatever architectural access openings may be necessary and furnish access doors or panels in building construction. Provide shop drawings indicating location of access panels or doors for Commissioner's approval.

- F. It is the intention of these plans and specifications to be complete. However, it is the responsibility of this Division, as being completely cognizant of local regulations, to determine where fire dampers are required and to advise the Commissioner prior to bid as to any discrepancies or questions in the plans or specifications.
- G. Fire dampers shall be enclosed in sleeve of fourteen gauge metal set and grouted into five partitions. Sleeve shall be secured at both sides of fire partitions with 1-1/2 x 1-1/2 x 1/4 ga. mounting angles secured to sleeves only. Provide duct breakaway connections, see detail on drawings.
- H. Dampers shall be steel plate, mounted to turn freely, in steelplate frame inserted in duct. Dampers shall be proportioned and weighted to close at once, if released from link with spring catches to hold closed, until manually reset. Dampers and frames to have suitable eyes, standard fusible-links, normally holding them open, but releasing upon contact with fire. Damper blades shall be mounted on corrosion resisting bearings. Damper shall close by gravity, moving with the air stream to full closed position against one-eighth (1/8) inch angle stop. Steel spring catch shall hold damper closed. Radius arm on shaft shall show position of damper. Submit details for approval.
- I. In stainless steel ductwork, provide stainless steel construction fire dampers similar to Fire Seal Model 119D.

2.6 FIRE/SMOKE DAMPERS AND DAMPER OPERATORS

- A. Manufacturers:
 - 1. Design Basis: Ruskin
 - 2. Other Acceptable Manufacturers:
 - a. National Controlled Air
 - b. Johnson Controls
 - c. Safe Air
 - d. Prefco
 - e. Air Balance
 - f. Greenheck
- B. Fire Damper Rating: UL Standard 555 Dynamic, 1-½ hour or 3 hours.
- C. Smoke Damper Rating: UL Standard 555S, Class II.
- D. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be leakage Class 2 (10 cfm/ft. at 1" w.g.).
- E. Damper Assembly:
 - 1. Type: 120 volt.
 - 2. Listing: UL 555S, UL555.
 - 3. Rating: Match wall rating.
 - 4. Failure Position: Fail closed.
 - 5. Fusible Link: 165°F fusible link.

- 6. Blade: Air foil.
 - 7. Seals: Mechanically fastened, rated up to 450°F.
- F. Where part of Smoke Control System.
- 1. Provide end switch for positive indication of damper position.
 - 2. Provide means to re-open damper remotely in the event thermal link trips. Allow for re-open up to elevated rating of 250°F.
- G. Combination fire/smoke dampers shall meet or exceed the following specifications. Frame shall be a minimum of 16 gage galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. The blades shall be airfoil shaped double skin construction with 14 gage equivalent thickness. Blade edge seals shall be silicone rubber designed to withstand 450°F and jamb seals shall be stainless steel flexible metal compression type. Blade action must be parallel blade or opposed as required.
- H. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 2000 fpm air velocity in the open position.
- I. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat equal to Ruskin model TS150. Firestat shall electrically and mechanically lock damper in a closed position when duct temperatures exceed 212°F and still allow appropriate authority to override Firestat and operate damper as may be required for smoke control functions. Damper must be operable while temperature is above 250°F. Firestat package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when damper is fully open; the other switch shall close when the damper is fully closed. Firestat and position indicator switches shall be capable of interfacing electrically with smoke detectors, building fire alarm systems, and remote indicating/control stations. Dampers shall be Ruskin Model FSD36 with TS150 Firestat package.

PART 3 - EXECUTION

3.1 INSTALLATION OF ACCESSORIES

- A. Install fire, smoke and ceiling dampers in accordance with manufacturer's instructions and the latest version of the Fire, Smoke and Radiation Damper Guide for HVAC Systems, published by SMACNA.
- B. Notify fire alarm provider of smoke damper control requirements and fire alarm interlocks.
- C. Install all dampers, including those furnished by control contractor.
 - 1. Caulk damper frames to ductwork.
 - 2. Make sure dampers are free to operate properly.
 - 3. Install parallel blade mixing dampers to two streams impinge on each other to facilitate mixing.
- D. Provide balance dampers at all branch take-off and where required to minimize balancing performed at diffuser face.

- E. Provide all balance dampers as shown on plans and any additional dampers necessary to provide a balanced system meeting all sound requirements.

END OF SECTION

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SECTION 23 34 00**FANS****PART 1 - GENERAL****1.1 QUALITY CONTROL**

- A. Provide fans with AMCA performance certification and label.
- B. Grease exhaust fan shall comply with NFPA 96 and be UL listed.

1.2 MOTOR HORSEPOWER

- A. Do not increase or decrease motor horsepower from that specified without written approval from Commissioner. See Section 23 05 01.

1.3 SUBMITTALS

- A. Manufacturer's Data: Submit manufacturer's product data including:
 - 1. Performance
 - 2. Size
 - 3. Type
 - 4. Options provided
 - 5. Fan curves
 - 6. Indicate Compliance with Section 1.1 where applicable.

PART 2 - PRODUCTS**2.1 CENTRIFUGAL FANS (CLASS I)**

- A. Manufacturers:
 - 1. Design Basis: As scheduled.
 - 2. Acceptable Manufacturers:
 - a. Greenheck
 - b. Buffalo
 - c. Trane
- B. Furnish and install as shown on the plans non-power overloading centrifugal fans with airfoil blades in sizes 24 and larger and plate-type blades in sizes 22 and smaller. Fans shall be of the specified size, arrangement, class and capacity. Fans having outlet velocities greater than those shown will not be acceptable.
- C. Housings of fans, Class I, having wheel diameters 36" and smaller shall be convertible for various directions of discharge. Side sheets shall be fastened to scroll sheets by means of a deep lockseam. Housing supports shall be of one-piece welded constructed. Housing for Class I fans, having wheel diameters over 36", shall have side sheets welded to scroll sheets. Housings shall be split into two or more sections with heavy flanges on each section for bolting together. Flanges joints shall be gasketed for air-tightness. Sealer shall be applied to joints between housing, inlet and housing support to prevent air leakage. The cutoff shall be of the rolled slope type and shall be wider and closer to the shaft at the suction side, then the drive side, for single width fans. Inlet collars on all sizes of single width fans shall extend beyond the

fan housing to provide a continuous duct connection. Inlet collars on convertible housings shall be round and on nonconvertible housing shall be square. Both inlet and discharge duct collars shall be drilled or punched at uniform intervals. Inlet cones shall be spun or die-formed to provide smooth air flow into the wheel with minimum shock and turbulence.

- D. Fans wheels shall be constructed of twelve deep airfoil blades, plate type blade in sizes 22 and smaller, backward inclined from the direction of rotation. Blades shall be securely welded to the spun rim and hub plate. Hubs shall be of close grined cast iron, securely riveted to the hub plate. All wheels shall be carefully trued after assembly and shall be carefully trued after assembly and shall be dynamically balanced.
- E. Fan shafts shall be of SAE 1040 hot rolled steel, accurately turned, ground and polished. Close tolerances shall be maintained where shaft makes contact with bearings and fan wheel hub. All fans shall have adjustable belt and drives and shall be driven by a minimum of two belts.
- F. Fans shall be equipped with precision anti-friction extra heavy duty bearings of the self-aligning, grease-packed, pillow block type having a grease seal that will prevent loss of lubricant and exclude dirt from the bearings. Lubrication fittings shall be provided on exterior of cabinet or housing. Average bearing life shall be min. 200,000 hours.
- G. All fans shall be given a bonding coat before painting. After the cleaning and surface conditioning process, but before assembly, parts shall be spray painted with one coat of grey primer-finisher. A second coat of the same paint shall be applied to the exterior and all accessible interior surfaces after the fan is assembled. Shafts shall have a rust-preventive coating.
- H. Fan ratings shall be based upon tests performed in strict accordance with the test code adopted jointly by the Air Moving and Conditioning Association and the American Society of Heating, Refrigeration and Air Conditioning Engineers. Each fan shall carry, near the manufacturer's nameplate, the seal authorized by AMCA indicating that ratings are certified. Fans not bearing this seal will not be acceptable.
- I. Fans shall be as scheduled on the Drawings.
- J. Provide 2" wire mesh inlet screens with each fan.

2.2 POWER ROOF VENTILATORS, CENTRIFUGAL

- A. Manufacturers:
 - 1. Design Basis: As scheduled
 - 2. Acceptable Manufacturers:
 - a. Greenheck
 - b. Cook
 - c. Carnes
 - d. Aerovent
 - e. Ammerman
 - f. Hurricane
 - g. Jenn Air
 - h. Penn
 - i. Powerline

B. Features:

1. Spun aluminum housing.
2. Internal rubber vibration isolators.
3. Ball bearings.

C. General:

1. Provide:
 - a. Bird screen.
 - b. Gravity back-draft damper:
 - 1) 0.2 inches WC max. pd.
 - c. Motorized type backdraft damper where indicated.

D. Roof Curb:

1. Provide dimension data to Supplier of roof curbs.
2. Provide factory fabricated roof curb of height required by local authorities.

E. Sound Criteria:

1. Required sound levels may be attained by use of sound attenuating curbs.
2. Fan shall have specified capacity with curb in place.
3. Curb pressure drop is not included in specified ratings.

PART 3 - EXECUTION**3.1 NOISE AND VIBRATION**

- A. Insure that fans are properly supported on vibration isolators. Reference Section 23 05 48 for Vibration Isolation Requirements.
- B. Insure that flexible duct connections are properly made.
- C. Check fan for improper balance and have fan re-balanced if necessary.
- D. Check for proper rotation.
- E. Check for unusual noise or vibration and correct as necessary.

3.2 ACCESS

- A. Provide for proper access to all parts of fan needing inspection or service with access doors in fan or ductwork.

3.3 INSTALLATION

- A. Install units level and plumb.
- B. Provide necessary auxiliary supporting steel.
- C. Mount motor and drives so belts run true.

- D. Provide necessary lubrication.
- E. Provide flexible duct connections on inlet and discharge.
- F. Provide 460v/120v transfer to serve controls and convenience outlet at all 460v fans.
- G. Provide unfused disconnect of suitable capacity. Disconnect shall be weatherproof where installed outside or in a location subject to wetness.
- H. Provide vibration isolators as recommended by manufacturer and other sections of this specification.

3.4 CURBS

- A. Provide necessary dimensions and details so roof opening can be provided at the proper time.
- B. Coordinate delivery of curb with roofing contractor so project is not delayed.
- C. Provide a weatherproof installation:
 - 1. Seal all joints including, but not limited to:
 - a. Unit and curb.
 - b. Unit and ducts.

END OF SECTION

SECTION 23 37 00**AIR INLETS AND OUTLETS****PART 1 - GENERAL****1.1 CEILING CONSTRUCTION**

- A. Provide products compatible with ceiling construction.

1.2 SUBMITTALS

- A. Submit catalog data including throw, sound, pressure drop, physical dimensions and color.

1.3 INDUSTRY STANDARDS

- A. Provide products tested in accordance with ASHRAE 70-1991 150 Standard 5219, 150 Standard 3741.

PART 2 - PRODUCTS**2.1 GRILLES AND RECTANGULAR DIFFUSERS**

- A. Manufacturers:

- 1. Design Basis: Titus
- 2. Other Acceptable Manufacturers:
 - a. Carnes
 - b. Anemostat
 - c. Metal Aire

- B. Material: Steel or aluminum except:

- 1. Where noted otherwise.
- 2. Where required otherwise for fire rating.
- 3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.

- C. Finish: Baked enamel with color selected by Commissioner.

- D. Refer to Drawings for required performance.

- E. Match frame and border types to ceiling system.

2.2 ROUND CEILING DIFFUSERS:

- A. Manufacturers:

- 1. Design Basis: Titus Series TMRA
- 2. Other Acceptable Manufacturers:
 - a. Carnes Series SSAA
 - b. Krueger
 - c. Metal Aire Series 3100
 - d. Anemostat

- B. Material: Steel or spun aluminum with 360° discharge pattern except:
 - 1. Where noted otherwise.
 - 2. Where required otherwise for fire rating.
 - 3. Grilles and diffusers in locker rooms, showers and toilet rooms in locker rooms to be aluminum.
- C. Finish: Anodized aluminum finish, color selected by Commissioner.
- D. Refer to the Drawings for required performance.
- E. Match frame and border types to ceiling system. Adjustable inner cones surrounded by a ceiling plate collar designed to reduce ceiling smudges.
- F. Diffusers as shown on drawings and/or as scheduled.

2.3 PERFORATED CEILING DIFFUSERS:

- A. Manufacturers:
 - 1. Design Basis: Titus PPS
 - 2. Other Acceptable Manufacturers:
 - a. Carnes Series SP or SL
 - b. Krueger
 - c. Metal Aire Series 7600
 - d. Anemostat
 - e. EH Price Series PDS
- B. Material: Steel or aluminum except:
 - 1. Where noted otherwise.
 - 2. Where required otherwise for fire rating.
 - 3. Grilles and diffusers in locker rooms, showers and toilet rooms in locker rooms to be aluminum.
- C. Finish: Baked enamel except where noted, color by Commissioner..
- D. Field adjustable pattern controllers accessible through removable or hinged face plate. Pattern controller mounted directly under the neck of the diffuser and fully adjustable for either side blow or control blow pattern.
- E. Provide round or square neck duct adapters for each unit for top connection or side connection as appropriate to the space.
- F. Refer to the Drawings for required performance.
- G. Match frame and border types to ceiling system.

2.4 SQUARE CEILING DIFFUSERS:

- A. Manufacturers:
 - 1. Design Basis: Titus TDC
 - 2. Other Acceptable Manufacturers:

- a. Carnes Series SK or SE
 - b. Krueger Series S
 - c. Metal Aire Series 5000
 - d. Anemostat
 - e. EH Price Model AMD
- B. Material: Steel or aluminum, louvered face furnished with frame type appropriate to installation, except:
 - 1. Where noted otherwise.
 - 2. Where required otherwise for fire rating.
 - 3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.
- C. Finish: Baked enamel except where noted, color by Commissioner.
- D. Louver cones shall be one-piece construction with no corner joints.
- E. Directional blow pattern as shown on the drawings and/or as scheduled.
- F. Refer to the Drawings for required performance.
- G. Match frame and border types to ceiling system.

2.5 SQUARE CEILING RETURN/EXHAUST GRILLES:

- A. Manufacturers:
 - 1. Design Basis: Titus PAR
 - 2. Other Acceptable Manufacturers:
 - a. Carnes
 - b. Krueger
 - c. Metal Aire
 - d. Anemostat
 - e. Price
- B. Material: Steel or aluminum perforated face furnished with frame type appropriate to installation, except:
 - 1. Where noted otherwise.
 - 2. Where required otherwise for fire rating.
 - 3. Grilles and diffusers in locker rooms, showers, kitchens, concessions, and toilet rooms to be aluminum.
- C. Finish: Baked enamel except where noted, color by Commissioner.
- D. Perforated face shall have 3/16-inch diameter holes on 1/4-inch staggered centers and no less than 51% free area.
- E. Refer to the Drawings for required performance.
- F. Match frame and border types to ceiling system.

2.6 SIDE –WALL REGISTERS AND GRILLES:

- A. Manufacturers:
 - 1. Design Basis: Titus series 300(supply) and series 350(return/exhaust)
 - 2. Other Acceptable Manufacturers:
 - a. Carnes model R series
 - b. Krueger series 880
 - c. Metal Aire series V4000 or H4000
 - d. Anemostat
 - e. EH Price model NM22S/T or C22S/3
- B. Material: Steel or aluminum except:
 - 1. Where noted otherwise.
 - 2. Where required otherwise for fire rating.
 - 3. Grilles and diffusers in locker rooms, showers and toilet rooms to be aluminum.
- C. Finish: Baked enamel except where noted, color by Commissioner.
- D. Double deflection type blade supply registers and supply grilles allow deflection adjustment in all direction.
- E. Opposed blade volume control damper supply registers, operable from face.
- F. Fixed blade (0°, 45°) core return and exhaust registers and grilles.
- G. Opposed blade volume control damper return registers, operable from face.
- H. Register and grille sizes as shown on drawings and/or as scheduled.
- I. Screw holes on surface counter sunk to accept recessed type screws.
- J. Refer to the Drawings for required performance.

PART 3 – EXECUTION**3.1 GENERAL**

- A. Refer to architectural reflected ceiling plan for exact locations and ceiling types.
- B. Install grilles, registers and diffusers as shown on drawings, in accordance with manufacturer's written instructions, and with recognized industry practices, to ensure that equipment complies with requirements and serve intended purposes.
- C. Coordinate with other work as necessary to interface installation of equipment with other components of systems.
- D. Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

- E. Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.
- F. Seal connections between ductwork drops and diffusers/grilles airtight.
- G. Blank off unused portion of linear slot diffusers and linear bar diffusers and grilles.
- H. Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.
- I. In clean rooms and animal holding rooms, caulk space between diffuser or grille and ceiling or wall to be air and watertight. Use clear, non-hardening silicone sealant compatible with ceiling or wall surfaces. Sealant shall be resistant to microbiological growth.
- J. Exposed mounting screws:
 - 1. Use tamper proof screws in countersunk holes.
 - 2. Point screws to match frame.
- K. Fire Rated Ceilings:
 - 1. Provide ceiling fire or fire/smoke damper that meets all applicable requirements of Section 23 33 00.
 - 2. Provide insulation equivalent to ceiling construction above diffuser between ceiling opening and ceiling damper.
- L. Install security type devices in accordance with manufacturer's directions.

3.2 INSPECTION

- A. Contractor shall examine location where this equipment is to be installed and determine space conditions and notify Commissioner in writing of conditions detrimental to proper and timely completion of the Work.
- B. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.3 FIELD QUALITY CONTROL

- A. Upon completion of installation of equipment, energized with normal power source, test equipment to demonstrate compliance with requirement. When possible, field correct malfunctioning units, then, retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected. Refer to Testing and Balancing.

END OF SECTION

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SECTION 23 52 00**BOILERS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of Contract, including General and Supplemental Conditions of the Construction Contract, and Division 1 Specification Sections (General Requirements), apply to this Section.

1.2 QUALITY ASSURANCE

- A. ASME Code Symbol Stamps: Provide boilers and safety (pressure relief) valves complying with ASME Code and stamped with appropriate code symbols.
- B. Equipment must be approved for installation in the city of New York and one with permanently mounted labels as required in the city of NY.
- C. Hydronics Institute Insignia: Provide cast-iron boilers, which have been I-B-R (Institute of Boiler and Radiator Manufacturers) performance rated and have affixed the I-B-R insignia of the Hydronics Institute.
- D. AGA Certification: Provide boiler of design certified by American Gas Association.
- E. Submittals:
 - 1. Submit manufacturer's product data.
- F. The burner and controls shall conform to the requirements of Industrial Risk Insurers (IRI), and Factory Mutual (FM).
- G. General Requirements for Boiler Suppliers:
 - 1. The Boiler Representative shall be an authorized representative of the Boiler manufacturer and shall have been actively engaged with this manufacturer and in this field of operation for not less than five years. The installing contractor or boiler supplier shall have a service department as a permanent and integral part of his company with 24-hour service available at all times. The contractor or boiler supplier's stocking warehouse shall be no more than 100 miles from the jobsite and stock standard replacement parts for the boiler.
 - 2. The entity responsible for boiler service during the warranty period and his 24 hour service phone number shall be specified in the O & M manual.
 - 3. The boiler representative shall provide a factory trained and factory authorized representative to perform the following:
 - a. Verify proper installation of boiler.
 - b. Verify installation of boiler gas train.
 - c. Verify proper wiring of controls and for proper operation of the controls in accordance with the boiler listing, manufacturer's directions and Sequence of Operation given in Section 23 09 00.
 - d. Adjust firing and perform combustion test. Testing shall be performed at full load conditions. The equipment and instruments required to perform the tests must meet with the approval of the Engineer.

- e. The above tests must be certified by the factory authorized representative performing the test.
- f. Provide free inspection and adjustment of the burner installation for the full warranty period of the installation.
- g. Adjust power burners to provide sea level output at the jobsite elevation.

1.3 REGULATORY REQUIREMENTS

- A. Comply with the requirements of all authorities having jurisdiction including but not limited to:
 - 1. State Boiler Inspector.
 - 2. NYC Building Department.
- B. Provide all gas train components, operating controls, safety controls, low water cut outs, and other components required for the occupancy of the building and the size of the boiler.

1.4 WARRANTY

- A. Provide a five (5) year warranty for boiler and burner components.

PART 2 – PRODUCTS

2.1 BOILERS (CAST IRON)

- A. Manufacturers:
 - 1. Design Basis: Weil McLain
 - 2. Other Acceptable Manufacturers:
 - a. Burnham
 - b. H.B. Smith
 - c. Hydrotherm
 - d. Slant Fin
 - e. Peerless
- B. Model: EG-65 STEAM
- C. Type:
 - 1. Sectional
 - 2. Pressurized fire box
- D. Burner: Power burner arranged for on/off operation with:
 - 1. Pre-purge
 - 2. Low fire start
 - 3. High fire run
 - 4. One position air control
 - 5. Post purge
- E. Burner Safety Controls:
 - 1. Ultraviolet flame detector
 - 2. Dual automatic gas valves
 - 3. Proven gas pilot

- 4. Air flow switch
- F. Burner: Atmospheric.
- G. Pressure Rating: As required for project.
- H. Fuel:
 - 1. Natural Gas
 - 2. 4" WC
- I. Control: Boiler controls shall be provided by the manufacturer to maintain desired water temperature. Controls shall be capable of interfacing with the temperature control system.
- J. Trim and Accessories:
 - 1. ASME rated relief valve, set at boiler pressure rating.
 - 2. Low water cut-off.
 - 3. High limit control.
 - 4. Operating control.
 - 5. Manual main gas shut-off valves.
 - 6. High pressure gas switches.
 - 7. Intermittent pilot.
 - 8. Safety pilot switches, 100% shut-off.
 - 9. Pilot filters.
 - 10. Gas pressure regulator.
 - 11. Pilot shut-off valves.
 - 12. Combination pressure temperature altitude gauge.
 - 13. Built-in air eliminator.
 - 14. Barometric damper.
 - 15. Heat damper.
- K. Burner Combustion Test:
 - 1. Burner shall be adjusted to not less than 9 to 9½% CO₂ at 0% CO (CO shall not exceed 200 ppm) and 4.5% O₂ on gas firing. Flue temperature shall not exceed 450°F.

2.2 BREAK GLASS SWITCH

- A. This Contractor shall furnish "emergency break glass switch(es)". Switch(es) shall be installed by Electrical Contractor adjacent to all boiler room entrances.
- B. Model: Weil-McLain or Asco No. 124323, surface mount, red cover labeled "to stop boilers".

PART 3 - EXECUTION

3.1 FIELD ASSEMBLY

- A. Assemble boiler at the job site in an area designated by the Owner, convenient for installation.
- B. Comply with all manufacturers' requirements.
- C. Upon completion of assembly, contact Engineer and manufacturer's representative for field observation.

3.2 CLEANING

- A. Flush and clean boilers upon completion of installation in accordance with manufacturer's instruction.
- B. Include boiler in system for cleaning covered in Section 23 21 13.

3.3 FIELD QUALITY CONTROL

- A. Test assembled boiler, boiler piping and accessories, including, but not limited to, safety and safety relief valves, gauges, etc., in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
- B. Arrange with Owner's insurance carrier and State Boiler Inspector for inspection and certification of completed boiler unit.
- C. Instruct the Owner's Representative in the proper operation of the boiler in the presence of the Boiler Representative.

3.4 WATER QUALITY

- A. Initial fill of boiler water system shall be treated with softeners and/or inhibitors as recommended by Boiler Manufacturer.
- B. Submit a water quality analysis by a qualified water treatment company to Boiler Manufacturer for his use in recommending water treatment.
- C. Submit water quality analysis and treatment recommendations to Engineer for review and comment.

3.5 START UP

- A. Manufacturer representative shall provide factory trained personnel to start up and checkout boilers. Adjust burner to provide optimum combustion as determined from flue gas analysis.

3.6 SPARE PARTS

- A. Provide an additive alternative price to the bid to provide the following boiler spare parts to the Owner for future use:
 - 1. Six (6) Bulbs for Indicating Lights
 - 2. One (1) Flame Rod
 - 3. One (1) Ignition Rod
 - 4. One (1) Flame Safeguard Control
 - 5. One (1) Blower Motor
 - 6. One (1) Blower Sheave
 - 7. One (1) Pilot Solenoid Valve

END OF SECTION

SECTION 23 82 19
ROOM TERMINAL UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Factory constructed vertical or horizontal Fan Coil Units.

1.2 RELATED WORK

- A. Section 23 05 13 – Motors and Starters.
- B. Section 23 37 00 – Air Inlets and Outlets.
- C. Section 23 09 00 – Building Automation and Automatic Temperature Control Systems.

1.3 REFERENCES

- A. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.
- B. SMACNA – HVAC Duct Construction Standards.

1.4 QUALITY ASSURANCE

- A. Fan Coil Units: Product of manufacturer regularly engaged in production of components that issues complete catalog data on total product offering.
- B. Fan Coil Units: Certify capacity, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430-89.
- C. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410-87.

1.5 SUBMITTALS

- A. Submit as-built drawings and product data under provisions of General Conditions.
- B. As-built drawings shall show unit configuration in direction of airflow, and shall indicate assembly and unit dimensions.
- C. Product data shall indicate dimensions, weights, capacities, fan performance, motor electrical characteristics, and finishes of materials.
- D. Submit product data of filter sizes and quantities, filter performance, and filter frames.
- E. Submit manufacturer's installation instructions under provisions of General Conditions.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of General Conditions.

- B. Include instructions for lubrication; filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 – PRODUCTS

2.1 BLOWER COIL FAN COILS (400 to 4,000 CFM)

- A. Design Basis: Trane
- B. Other Acceptable Manufacturers:
 - 1. First Company
 - 2. International Environmental
 - 3. Magic Aire
 - 4. McQuay
 - 5. York
- C. Construction
 - 1. See drawings for unit configuration.
 - 2. 18 gauge galvanized steel.
 - 3. ABS or stainless steel drain pan, positively sloped in every plane.
 - 4. Thermoplastic secondary drain pan.
 - 5. All parts exposed to moisture are to be galvanized.
 - 6. Insulate unit throughout with 1-½ LB closed cell foil faced insulation.
 - 7. Motor access panels on either side of unit.
 - 8. Mixing box with ½" extended drive rod, and low leakage dampers with edge seals. Mixing box to allow 100% economizer operation.
- D. Filters
 - 1. See drawings for filter efficiency.
 - 2. Filter rack, sized to provide maximum of 500 fpm across filter.
- E. Fan
 - 1. Fan to be forward curved centrifugal blower.
 - 2. Provide adjustable v-belt drive.
 - 3. Fan shaft to be supported by heavy duty permanently sealed ball bearings.
 - 4. Fan and housing are corrosion resistant.
- F. Motor
 - 1. Provide integral overload protection.
 - 2. Motor to be permanently lubricated.
 - 3. Fan Motors shall be heavy duty, high efficiency, and open drip-proof.
 - 4. Motor horsepower shall not be changed without written approval from the Engineer.

G. Coils

1. Coils are leak tested at 350 PSIG minimum air pressure, suitable for working pressures up to 250 PSIG with air vents
2. Coils shall be designed with aluminum plate fins and copper tubes.
3. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 440.
4. Provide factory installed extended drain and vent connections for water coils.

2.2 HORIZONTAL OR VERTICAL CASED FAN COIL UNITS (300 to 1300 CFM)

A. Basis of Design: International Environmental

B. Acceptable Manufacturers

1. First Company
2. Magic Aire
3. McQuay
4. Trane Company
5. York

C. Construction

1. See drawings for unit configuration.
2. 18 gauge galvanized steel.
3. For exposed units, provide baked powder finish in standard color. Color selection by architect.
4. ABS or stainless steel drain pan, positively sloped in every plane.
5. Thermoplastic secondary drain pan.
6. All parts exposed to moisture are to be galvanized.
7. Insulate unit throughout with closed cell insulation.
8. Refrigerator style leveling feet for vertical units.
9. Provide piping end pocket.

D. Fan

1. Aluminum, direct drive fan wheel and sheet metal housing.
2. Fan wheel to be forward curved, double width.
3. Fan and housing are corrosion resistant.

E. Motor

1. Provide permanent split capacitor and integral overload protection.
2. Motor to be permanently lubricated.
3. Motor shall be able to start at 78 percent of rated voltage and operate at 90 percent of rated voltage on all speed settings.
4. Three speed fan switch to be mounted on unit housing.

F. Coils

1. Coils are leak tested at 350 PSIG minimum air pressure, suitable for working pressures up to 250 PSIG with air vents

2. Coils shall be designed with aluminum plate fins and copper tubes.
3. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 440.
4. Provide factory installed extended drain and vent connections for water coils.

PART 3 - EXECUTION

3.1 GENERAL

- A. Assemble and install in accordance with manufacturers written installation instructions and details on drawings.
- B. Coordinate duct, piping and electrical work so as to provide access to unit for maintenance and filter replacement and coil removal with minimum disturbance of piping and no demolition of room construction or finishes.
- C. Prior to unit start-up all controls shall be installed and tested.
- D. Prior to initial start-up and for system testing install air filters to protect the unit and ductwork from dirt and debris. After the system has been tested and prior to turning the system over to the Owner, replace the pre-filters with new, clean filters as specified.
- E. Prior to turning the system over to the Owner, all damages incurred during shipping, storing and installing shall be repaired. These repairs shall be sufficient to bring the equipment back to the quality standards, equal to the original manufacturing standards. These repairs shall include but are not limited to repairing painted surfaces, dent removal, combing coil fins, repairing or replacing wet, sagging or torn insulation, etc.
- F. Pipe condensate full size to nearest floor drain. Provide trap 1" greater than fan static pressure.
- G. Install units with adequate clearances as to:
 1. Allow access to valves
 2. Allow for coil pull, filter replacement and maintenance
 3. Allow access doors to fully open
 4. Provide required NEC clearances in front of disconnect and electrical components.

END OF SECTION

SECTION 23 82 39
HEATING TERMINAL UNITS

PART 1 - GENERAL**1.1 SUBMITTALS**

- A. Submit manufacturer's product data:
 - 1. Performance data.
 - 2. Drawings.
 - a. Dimensions
 - b. Support requirements
 - c. Size and location of connections
 - 3. Enclosure gauges.
 - 4. Accessories.
 - 5. Parts lists.
 - 6. Additional Submittal Requirements for Fan Coil Units, Cabinet Heaters and Unit Heaters:
 - a. Wiring diagrams.
 - b. Installation, operating and maintenance instructions.

PART 2 - PRODUCTS**2.1 GENERAL**

- A. Except as otherwise indicated, provide manufacturer's standard products as indicated by published product information, and as required for a complete installation.

2.2 FINNED TUBE RADIATION

- A. Manufacturers:
 - 1. Design Basis: Slant Fin Corp.
 - 2. Other Acceptable Manufacturers:
 - a. Airtherm Mfg. Co.
 - b. Dunham-Bush Inc.
 - c. Edwards Industries Inc.
 - d. Rittling
 - e. Vulcan.
 - f. Trane Co.
 - g. Sterling
 - h. Mark Hot
 - i. Ted Reed Thermal
- B. Provide finned tube radiation complete with enclosures of one piece back panel, one piece front panel, heating element, hangers and accessories.
- C. Fin tube radiation shall be I.B.R. rated.

- D. Enclosure front panel, one-piece #14 USSG Steel cabinet, with outlets as indicated on drawings. Each enclosure front panel shall be rigidly braced by integral vertical channel braces in at least two locations. Each front panel shall extend to wall and be fastened to back panel at both top and bottom. Enclosures shall be finished with baked-on gray enamel primer and final baked enamel finish, color as selected by the Commissioner.
- E. Back panel, one-piece construction #20 USSG steel, shall provide continuous support at both top and bottom for rigid fastening of front panel. Back panel, shall be pre-punched for fastening to wall and for attaching of heating element hangers.
- F. Support brackets minimum 4'-0" on centers for heating element shall attach to back panel; vertically adjustable for pitch, and providing free longitudinal movement for expansion and contraction. Where pipe runs under enclosures they too shall be supported from back panel. No sheet metal screws or other fastening devices shall be visible when enclosure is installed below eye-level. Where two or more enclosure sections are joined end to end, rolled enclosures edges shall form neat butt joint without butt straps or other concealing devices. No unfinished metal edges shall be visible in the installed ensemble.
- G. Where fin tube radiation with expanded metal cover is used, it shall be same element as specified for enclosed fin-tube radiation.
- H. Fin tube elements shall have a capacity as shown on the Drawings when supplied with steam. Elements shall be 1-1/4" IPS with 5-1/4" x 5-1/4" steel fins spaced 40 per foot, unless otherwise noted on the Drawings as copper. All elements shall be one row high unless otherwise noted on the Drawings.
- I. Provide end caps where radiation terminates at doors, walls, pilasters or columns and inside or outside corners where required.
- J. Provide knob-operated dampers above all radiation where radiation is not controlled by individual room automatic control valves. Provide access doors in enclosures at balancing valves, shut-off valves and air vents.
- K. All radiation enclosures and access door locations shall be field measured prior to fabrication.
- L. Provide sponge rubber gasket between enclosure and wall.

2.3 STEAM CABINET UNIT HEATERS

- A. Manufacturers:
 - 1. Design Basis: Trane.
 - 2. Other Acceptable Manufacturers:
 - a. Carrier
 - b. Modine
 - c. McQuay
 - d. Mark Hot
 - e. Sterling
 - f. Vulcan

B. Construction:

1. Coils:
 - a. Fins: Aluminum.
 - b. Tubes: Copper.
 - c. Working Pressure: 250 psig.
2. Casing:
 - a. Material: 16 gauge steel.
 - b. Corners: Rounded, 1" minimum radius.
 - c. Finish: Phosphatized and painted inside and out with one coat of baked-on enamel.
 - d. Color: Selected by commissioner from manufacturer's standard colors.
 - e. Heating Element Supports: Adjustable.
 - f. Gaskets: Between front panel and enclosure.
3. Grilles: Fabricated steel bar grille.
 - a. Directional Louvers: Under grille.
4. Fans:
 - a. Arrangement: Blow-through
 - b. Type: Multi-wheel, DWDI, FC, aluminum.
 - c. Balance: Factory balance, static and dynamic.
 - d. Drive: Direct.
5. Motors:
 - a. Type: Shaded pole, permanently lubricated.
 - b. Insulation: Class B.
 - c. Speeds: Three.
 - d. Protection: Built-in thermal overload.
6. Filters: Disposable, ¾" or 1" thick.
7. Filters: Permanent.
 - a. Type: Permanent.
 - b. Material: Metal.
 - c. Thickness: 1"

- C. Basic unit shall include chassis, coil, fanboard, fanwheel(s), housing(s), motor and insulation. Chassis is galvanized steel wrap-around structural frame with all edges flanged. Insulation is faced, heavy density glass fiber.

D. Vertical Cabinet Models

1. 16 gauge steel front panels and 18 gauge steel end and top panels have channel-formed edges around entire panel perimeters. Front panel insulated over entire coil section. Integral, stamped outlet grilles have 15° deflection from vertical. Stamped lattice discharge grilles on inverted airflow models. Access door on coil connection side of unit. Front panel removable without tools.

E. Vertical Recessed Models

1. 16 gauge steel, four-side overlap front panels, with "M"-shaped stiffener running entire panel length as standard. Integral, stamped inlet and outlet grills have 15° downward deflection. Front panel insulated over entire coil section. Front camlocked access doors on righthand side of unit. Front panel removed with two screws.

F. Horizontal Cabinet Models

1. 18 gauge steel panels. Bottom and end panels have channel-formed edges around entire panel perimeter. Integral, stamped outlet grilles have 15° downward deflection. Stamped lattice inlet grilles. Bottom panel hinged at front and camlocked at back.

G. Horizontal Recessed Models

1. 18 gauge steel, removable, four-side overlap bottom panel adjustable 3/8" with full length, piano-type hinge at back and camlocks at front.

H. Steam Coils

1. 1" OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 75 psig for Type B steam coil, and 100 psig on Type F steam distributing coil. Factory leaktest 250 psig (air under water). Maximum entering steam temperature 325°F for standard coil (Type B) and 400°F for steam distributing coil (Type F). Steam distributing coils have cast iron headers. Supply and return connections on same side of units on all models and sizes.

I. Fans

1. Fan wheels centrifugal, forward-curved, double of non-corrosive, molded, fiberglass-reinforced thermo-plastic material on all units except electric heat and inverted airflow models which use aluminum. Fan housings of formed sheet metal on 200-600 cfm units. 800-1800 cfm units have end caps made of non-corrosive, molded, fiberglass-reinforced thermo-plastic material, and fan scrolls of galvanized steel.

J. Motors

1. All motors have integral thermal overload protection and start to 78% of rated voltage. Motors operate satisfactorily at 90% of rated voltage on all speed settings and at 10% over voltage without undue magnetic noise. Temperature rise by winding resistance method shall not exceed 60°C (shaded pole motors) and 50°C (PSC motors) on high speed. All motors factory run tested assembled in unit prior to shipping. Motor cords shall be quickly detachable at junction box by locking prong connection or vertical cabinet and wall hung units.

K. Electrical Performance

1. All units shall be wired in accordance with National Electric Code. Underwriters Laboratories, Inc. listed. Provide a junction for motor cord.

L. Motor Starters

1. Motors starters shall isolate the units from electric power source for maintenance. Thermal overload device shall protect motor. Overload mechanism shall reset by moving toggle switch to "Off" and then "On" position.

2. Unit shall be provided with "Off-Heat-Vent" selector switches. Switches shall be factory mounted on units accessible from the floor and loose (for installation under this Contract) for units not accessible from the floor.

PART 3 – EXECUTION

3.1 GENERAL

- A. Locate units so clearance is provided for:
 1. Service and maintenance.
 2. Enclosure removal.
- B. Level or pitch elements as required:
 1. Install shims if necessary.
- C. Touch-up finish after final adjustment.
- D. Replace damaged enclosures.
- E. Straighten bent fins.
- F. Replace damaged elements.

END OF SECTION

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SECTION 23 90 00**PROJECT CLOSEOUT****PART 1 – GENERAL****1.1 WORK INCLUDED**

- A. The contractor shall summarize and document adherence with the requirements of the specifications for project closeout including:
1. Copies of all warranties
 2. Operation & Maintenance Manuals
 3. Required tests
 4. Test and balance reports
 5. Record drawings
 6. Permit requirements
 7. Valve tag list
- B. The contractor shall compile a closeout manual which shall include:
1. A list of all required tests and a place for signoff of date completed.
 2. A list of all submittals with dates of acceptance by the engineer.
 3. A schedule indicating dates for beginning testing and startup of equipment and dates of tests to be witnessed by the engineer, or designated representative, as required by the specifications.
 4. Test procedures to be used for life safety systems.
 5. Project close out check list.
- C. The final closeout manual shall include the following:
1. Test reports as required by the specifications with signoff by the appropriate individual (engineer, commissioner, building official, etc.).
 2. Documentation indicating all equipment is operating properly and is fully accessible for maintenance.
 3. Copies of all warranties.
 4. Test and Balance report.
- D. This section only includes the requirements for documentation of the contract documents, by the contractor, for project completion. This section does not in any way decrease the scope of any of the drawings or specifications.

1.2 SUBMITTALS

- A. Within 90 days after notice to proceed submit a preliminary closeout manual with the following:
1. A list of all required tests.
 2. Preliminary schedule showing major milestones for completion of the mechanical systems.
- B. Within 30 days of the first major milestone submit the completed closeout manual as described in Part 1.

- C. Within 2 weeks of substantial completion submit a completed "Project Closeout Check List", and the Final Closeout Manual.
- D. Listed below is a checklist for use by the contractor. This list is not all inclusive for this project.

Project Close-Out Summary – Mechanical

- ☐ All required submittals have been submitted and either been approved or modified in accordance with the Engineer's "make corrections noted" comments.
- ☐ Clean filters installed in all units. (Install just prior to building turnover)
- ☐ All equipment has been started up and is functioning within manufacturers' recommendations without any undue noise or vibration. (Submit a list of equipment with startup dates. Provide list at a point 65% into construction schedule).
- ☐ All vibration isolation has been installed and is operating properly.
- ☐ Duct access doors have been installed at fire and fire/smoke dampers and are properly fire-stopped and fire and fire/smoke dampers have been visually inspected to confirm that they are open.
- ☐ Access doors have been installed as required for concealed equipment, water hammer arrestors, valves, controls, actuators, etc.
- ☐ Chemical treatment system installed per specification and functioning properly.
- ☐ All equipment has been installed with the manufacturers recommended service clearances and is fully accessible for required maintenance.
- ☐ All equipment and piping is labeled per specifications.
- ☐ All piping cleaned, flushed and tested per specifications. Submit all required test and balance reports for record.
- ☐ All action items are complete as listed in the action items reports. Submit a list of action items with sign off by Commissioner for record. Punch list to be completed prior to turn over of building.
- ☐ Temperature control system complete and tested per specifications.
- ☐ Test and balance complete and report submitted and accepted by Engineer.
- ☐ Operation and maintenance manuals submitted with table of contents and required documentation for extended warranties.
- ☐ Factory Testing documented and submitted for record.
- ☐ Record drawings submitted per specifications.
- ☐ Temperature Control record documents provided per specifications.
- ☐ Temperature Control Point to point checkout documents submitted.

PART 2 – PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 EQUIPMENT STARTUP AND TESTING

- A. Prior to completion and punchlist by the engineer, the contractor shall startup and test each piece of equipment as required by the specifications. The contractor shall provide documentation of all required tests with signoff of by the appropriate individual (engineer, commissioner, and building official).

3.2 LIFE SAFETY SYSTEMS

- A. All life safety systems shall be fully and successfully tested by the contractor before being witnessed by the engineer or building official
- B. The contractor shall provide a detailed test procedure, with instrumentation to be used, for approval by the engineer and building official prior to any testing.
- C. Once tested by the contractor and fully operational, the systems shall be demonstrated to the engineer. Once accepted by the engineer the system shall be demonstrated to the building and fire officials.

3.3 COORDINATION WITH OTHERS

- A. The Division 21 through 23 contractor shall coordinate his requirements with the General Contractor to ensure the other building systems are completed to the point that they will not adversely affect the operation of the Division 21 through 23 systems.

END OF SECTION

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