SECTION 15015

VENDOR ENGINEERED FIRE-SUPPRESSION SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section, including but not limited to:

1. Division 1 Section "Contract Procedures".
2. Division 1 Section "AIA 201 – General Conditions of the Contract for Construction".
3. Division 7 Section "Through-Penetration Firestop Systems".

1.02 SUMMARY

A. This Section includes fire-suppression piping and equipment for the following building systems:

1. Wet-pipe, fire-suppression sprinklers, including piping, valves, specialties and automatic sprinklers.

B. Related Sections include the following:

1. Division 15 Section "Basic Mechanical Materials and Methods."
2. Division 15 Section "Mechanical Identification."
3. Division 15 Section "Hangers and Supports."
4. Division 7 Section "Through - Penetration Firestop Systems."
5. Division 15 Section "Mechanical Vibration and Seismic Controls".

1.03 DEFINITIONS

A. Working Plans: Documents, including drawings, calculations, and material specifications prepared according to NFPA 13 and NFPA 14 for obtaining approval from authorities having jurisdiction.

1.04 SYSTEM PERFORMANCE REQUIREMENTS

A. Design sprinkler systems and obtain approval from all authorities having jurisdiction including Owner's Insurance Underwriter and Fire Marshal.

B. Design sprinkler piping according to the following and obtain approval from authorities having jurisdiction:

1. Include 10 percent margin of safety for available water flow and pressure.
2. Include losses through water-service piping, valves, and backflow preventers.
3. Sprinkler Occupancy Hazard Classifications: As follows:

a. Building Service Areas: Ordinary Hazard, Group 1.

b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
c. General Storage Areas: Ordinary Hazard, Group 1.
d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
e. Office and Public Areas: Light Hazard.
f. Restaurant Service Areas: Ordinary Hazard, Group 1.

g. Consult Owner's Insurance Underwriter and other authorities having jurisdiction and modify requirements accordingly.

4. Minimum Density for Automatic-Sprinkler Piping Design: As follows:

a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500- sq. ft. area.
c. Consult Owner's Insurance Underwriter and other authorities having jurisdiction and modify minimum requirements accordingly.

5. Maximum Protection Area per Sprinkler: As follows:

a. Office Space: 225 sq. ft.
b. Storage Areas: 130 sq. ft.
c. Mechanical Equipment Rooms: 130 sq. ft.
d. Electrical Equipment Rooms: 130 sq. ft.
e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.
f. Consult Owner's Insurance Underwriter and other authorities having jurisdiction and modify requirements accordingly.

C. Components and Installation: Capable of producing piping systems with 175-psig minimum working-pressure rating, unless otherwise indicated.

D. Final design of fire suppression system is the responsibility of the Fire Protection Contractor. All documents to be stamped by a State of Maine Licensed Professional Fire Protection Engineer, provided by Fire Protection Contractor.

1.05 SUBMITTALS

A. Product Data: For the following:

1. Pipe and fitting materials and methods of joining for standpipe piping.
2. Pipe and fitting materials and methods of joining for sprinkler piping.
3. Pipe hangers and supports.
4. Piping seismic restraints.
5. Valves, including specialty valves, accessories, and devices.
6. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
7. Materials and methods of fire stopping fire suppression systems.
8. Pipe markers, valve tags and other signage for fire suppression systems.
9. Fire pump controller and automatic transfer switch.

B. Fire-Hydrant Flow Test Report: As specified in "Preparation" Article.

C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction. Include hydraulic calculations.

D. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping."

E. Maintenance Data: For each type of sprinkler specialty to include in maintenance manuals specified in Division 1.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project and obtained design approval and inspection approval from authorities having jurisdiction.

B. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer. Base calculations on results of fire-hydrant flow test.

C. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of fire-suppression piping that are similar to those indicated for this Project in material, design, and extent.

D. Manufacturer Qualifications: Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL's "Fire Protection Equipment Directory" and FM's "Fire Protection Approval Guide" and that comply with other requirements indicated.

E. Sprinkler Components: Listing/approval stamp, label, or other marking by a testing agency acceptable to authorities having jurisdiction.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

G. NFPA Standards: Equipment, specialties, accessories, installation, and testing complying with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounting steel cabinet and hinged cover, with space for a minimum of six spare sprinklers plus sprinkler wrench. Include the number of sprinklers required by NFPA 13 and wrench for sprinklers. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Sprinklers:

a. Central Sprinkler Corp.
b. Reliable Automatic Sprinkler Co., Inc.
c. Viking Corp.

2. Fire Pump Transfer Switch and Controller:

a. Firetrol.

b. Joslyn Clark.
c. Hubbell.

3. Keyed Couplings for Steel Piping:

a. Central Sprink, Inc.
b. Victaulic Co. of America.
c. Tyco

2.02 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.03 PIPES AND TUBES

A. Standard-Weight Steel Pipe: ASTM A 53, ASTM A 135, or ASTM A 795; Schedule 40 in NPS 2 and smaller.

B. Schedule 10 Steel Pipe: ASTM A 135 or ASTM A 795, Schedule 10 in NPS 2-1/2 and larger.

2.04 PIPE AND TUBE FITTINGS

A. Cast-Iron Threaded Flanges: ASME B16.1.

B. Cast-Iron Threaded Fittings: ASME B16.4.

C. Malleable-Iron Threaded Fittings: ASME B16.3.

D. Steel, Threaded Couplings: ASTM A 865.

E. Steel Welding Fittings: ASTM A 234/A 234M, ASME B16.9, or ASME B16.11.

F. Steel Flanges and Flanged Fittings: ASME B16.5.

G. Steel, Grooved-End Fittings: UL-listed and FM-approved, ASTM A 47, malleable iron or ASTM A 536, ductile iron; with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

2.05 JOINING MATERIALS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for pipe-flange gasket materials and welding filler metals.

B. Steel, Keyed Couplings: UL 213 and AWWA C606, for steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gaskets, and steel bolts and nuts. Include listing for dry-pipe service for couplings for dry piping.

C. Transition Couplings: AWWA C219, sleeve type, or other manufactured fitting the same size as, with pressure rating at least equal to, and with ends compatible with piping to be joined.

2.06 SPRINKLERS

A. Automatic Sprinklers: With heat-responsive element complying with the following:

1. UL 199, for applications except residential.
2. UL 1767, for early suppression, fast-response applications.

B. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

C. Sprinkler types, features, and options include the following:

1. Concealed ceiling sprinklers, including cover plate.
2. Quick-response sprinklers.

D. Sprinkler Finishes: Chrome-plated, bronze, and painted.

E. Special Coatings: Corrosion-resistant paint.

F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

G. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

H. New sprinklers to match existing sprinklers in facility.

2.07 SPECIALTY SPRINKLER FITTINGS

A. Specialty Fittings: UL listed and FM approved; made of steel, ductile iron, or other materials compatible with piping.

B. Locking-Lug Fittings: UL 213, ductile-iron body with locking-lug ends.

C. Mechanical-T Fittings: UL 213, ductile-iron housing with pressure-responsive gasket, bolts, and threaded or locking-lug outlet.

D. Mechanical-Cross Fittings: UL 213, ductile-iron housing with pressure-responsive gaskets, bolts, and threaded or locking-lug outlets.

E. Drop-Nipple Fittings: UL 1474, with threaded inlet, threaded outlet, and seals; adjustable.

2.08 FIRE PUMP CONTROLLER WITH TRANSFER SWITCH

A. Main Fire Pump Controller with Transfer Switch

1. The main fire pump controller shall be factory assembled and wired with a power transfer switch listed by Underwrites' Laboratories, Inc. for transfer switch and fire pump service. The power transfer switch shall be approved by Factory Mutual.
2. The power transfer switch and fire pump controller shall be factory assembled, wired and tested as a single unit and shall conform to all requirements of the latest edition of NFPA20, Centrifugal Fire Pumps and NFPA 70, National Electrical Code.

B. Power Transfer Switch for Generator Set Emergency Power Source

1. The power transfer switch shall be housed within the fire pump controller enclosure or in a NEMA Type 2 (IEC IP11) drip-proof enclosure attached directly to the fire pump controller. Where the power transfer switch is provided in an attached enclosure, the enclosures shall be fitted so that the assembly constitutes a single unit. The fire pump controller/power transfer switch shall be factory assembled, wired and tested as a unit prior to shipment.

2. The power transfer switch shall include a motor rated disconnect/isolating switch capable of interrupting the motor locked rotor current. The disconnect/isolating switch shall be mechanically interlocked so that the enclosure door cannot be opened with the handle in the ON position except by a hidden tool operated defeater mechanism. The disconnect/isolating switch shall be capable of being padlocked in the OFF position with up to three padlocks for installation and maintenance safety, and shall also be capable of being locked in the ON position. The enclosure door shall have a locking type handle and three-point cam and roller type vault hardware.
3. An auxiliary contact shall be provided on the transfer switch to prevent starting of the emergency generator set when the transfer switch or the main fire pump controller are being serviced.
4. The transfer switch circuitry shall be capable of sensing both the normal power source and the emergency power source. The normal power source pickup shall be set at 95 nominal voltage. The emergency power source shall be set to pick up at 90 nominal voltage and 95 nominal frequency All voltage sensing, frequency sensing, and time delays shall be field adjustable to accommodate individual installation requirements. The transfer signal shall be delayed for one second, delaying the transfer and engine start signals so as to compensate for momentary, normal power outages. An automatic delay of three seconds shall be provided upon transfer to or from the emergency power source to allow the motor to slow sufficiently, preventing line disturbances that could trip either the generator set or fire pump circuit breakers.
5. The transfer switch shall have TRANSFER SWITCH NORMAL, TRANSFER SWITCH EMERGENCY and EMERGENCY ISOLATING SWITCH OFF LED's, TEST and TRANSFER BYPASS switches, an audible alarm device and SILENCE ALARM pushbutton mounted on the flange of the enclosure. The power transfer switch shall be furnished with both normally open and normally closed auxiliary contacts for an engine start signal when normal power failure occurs. Auxiliary contacts shall also be provided and wired to terminals to indicate the transfer switch position. The transfer switch shall be electrically operated and mechanically held, and shall be capable of being operated by a manual transfer mechanism located on the switch.
6. The power transfer switch shall be a Firetrol FTA900 for normal utility power and engine generator set emergency power or approved equal.

C. Main Fire Pump Controller

1. The main fire pump controller shall be a factory assembled, wired and tested unit and shall conform to all the requirements of the latest edition of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection* and NFPA 70, *National Electrical Code*.
2. The controller shall be listed by Underwriters Laboratories, Inc., in accordance with UL218, *Standard for Fire Pump Controllers*, CSA, and Canadian Standards Association CSA-C22.2, *Standard for Industrial Control Equipment* (cULus), approved by Factory Mutual for fire pump service.

    a. The controller shall be of the combined manual and automatic type designed for full voltage starting of the fire pump motor having the horsepower, voltage, phase and frequency rating shown on the drawings. All information indicated on Drawings to be confirmed by the Fire Protection Sub-Contractor. The controller components shall be housed in a NEMA Type 2 (IEC IP11) drip-proof, wall mounted enclosure.
    b. All controller components shall be front mounted, wired and front accessible for maintenance. The minimum withstand rating of the controllers shall not be less than 100,000 Amps RMS Symmetrical at 200-600 Volts*. If the available system fault current exceeds these ratings, the controllers shall be supplied with a withstand rating of 150,000 or 200,000 Amps RMS Symmetrical, as required.

c. The controller shall include a motor rated combination isolating disconnect switch/circuit breaker, mechanically interlocked and operated with a single, externally mounted handle. When moving the handle from OFF to ON, the interlocking mechanism shall sequence the isolating disconnect switch ON first, and then the circuit breaker. When the handle is moved from ON to OFF, the interlocking mechanism shall sequence the circuit breaker OFF first, and then the isolating disconnect switch.

d. The isolating disconnect switch/circuit breaker shall be mechanically interlocked so that the enclosure door cannot be opened with the handle in the ON position except by a hidden tool operated defeater mechanism. The isolating disconnect switch/circuit breaker shall be capable of being padlocked in the OFF position for installation and maintenance safety, and shall also be capable of being locked in the ON position without affecting the tripping characteristics of the circuit breaker. The controller door shall have a locking type handle and three-point cam and roller vault type hardware. The circuit breaker trip curve adjustment shall be factory set, tested and sealed for the full load amps of the connected motor. The circuit breaker shall be capable of being field tested to verify actual pick up, locked rotor, and instantaneous trip points after field installation without disturbing incoming line and load conductors.

3. Operator Interface

a. The fire pump controller shall feature an operator interface with user keypad. The interface shall monitor and display motor operating conditions, including all alarms, events, and pressure conditions. All alarms, events, and pressure conditions shall be displayed with a time and date stamp. The display shall be a 2-line, 20-character, vacuum fluorescent, dot matrix type designed to allow easy viewing from all angles and in all light conditions. The display and interface shall be NEMA rated for Type 2, per2.8(B) and 2.8(C) protection and shall be fully accessible without opening the controller door. The display and user interface shall utilize multiple levels of password protection for system security. A minimum of 3 password levels shall be provided. The display shall be capable of being programmed for any language.

b. The fire pump controller operator interface shall be capable of displaying true RMS digital motor voltage and current measurements for all three phases simultaneously. Displays requiring push-button and selector switches to toggle between phases or current and voltage shall not be accepted.

c. Voltage and current shall be measured by True RMS technology to provide the most accurate measurement for all sine waves, including non-sinusoidal waveforms. Average responding meters will not be accepted.

d. The digital display shall indicate text messages for the status and alarm conditions of:

- Motor On
- Minimum Run Time / Off Delay Time
- Fail to Start
- Under Voltage
- Locked Rotor Trip
- Over Frequency
- Motor Over 320
- Motor Overload
- Sequential Start Time
- Local Start
- Remote Start
- System Battery Low
- Over Voltage
- Low Suction Pressure
- Emergency Start

e. The Sequential Start Timer and Minimum Run Timer/ Off Delay Timer shall be displayed as numeric values reflecting the value of the remaining time.

f. LED indicators, visible with the door closed, shall indicate:

- Power On
- Pump Running
- Alarm
- Deluge Open
- Phase Failure
- Interlock On
- Emergency Isolating Switch Open
- Low System Pressure
- Transfer Switch Normal
- Transfer Switch Emergency
- Phase Reversal

g. In addition to the standard alarm contacts required by NFPA20, the digital display module shall have N.O. and N.C. contacts for remote indications of any digitally displayed alarm and N.O. and N.C. contacts for remote indication up to EIGHT, specified, programmable alarm. N.O. and N.C. contacts shall be provided for "Fire Pump Running" alarm. This alarm shall be interfaced with the Building Automation System, (BAS). Manufacture of fire pump controller/automatic transfer switch shall coordinate interface requirements with BAS sub-contractor.

h. The digital display shall monitor the system and log the following data:

- Motor Calls/Starts
- Last Trip Currents
- Last Breaker Trip
- Minimum Voltages
- Maximum Voltages
- Last Phase Failure
- Last Phase Reversal
- Min/Max Pressure
- Elapsed Motor Run Time
- Elapsed Power On Time
- Maximum Run Currents
- Minimum Run Currents
- Last Motor Run Time
- Last Start Currents
- Min/Max Frequency

4. Event Recording

a. Memory - The controller shall record all operational and alarm events to system memory. All events shall be time and date stamped and include an index number- The system memory shall have the capability of storing 3000 events and allow the user access to the event log via the user interface. The user shall have the ability to scroll through the stored messages in groups of 1, 10, or 100.

b. Communications - The controller shall feature two independent communications ports to allow connectivity to computers, modems, or building management systems.

5. Solid State Pressure Transducer

a. The controller shall be supplied with a solid state pressure transducer with a range of 0-300 psi (0-20.7 bar) ±1 psi. The solid state pressure switch shall be used for both display of the system pressure and control of the fire pump controller. Systems using analog pressure devices or mercury switches for operational control will not be accepted.

b. The START, STOP and SYSTEM PRESSURE shall be digitally displayed and adjustable through the user interface. The pressure transducer shall be mounted inside the controller to prevent accidental damage. The pressure transducer shall be directly pipe mounted to a bulkhead pipe coupling without any other supporting members. Field connections shall be made externally at the controller coupling to pre-vent distortion of the pressure switch element and mechanism.

6. Operation

   a. A digitally set On Delay (Sequential Start) timer shall be provided as standard. Upon a call to start, the user interface shall display a message indicating the remaining time value of the On Delay timer.
   b. The controller shall be field programmable for manual stop automatic stop. If set for automatic stopping, the controller shall allow the user to select either a Minimum Run Timer or an Off Delay Timer. Both timers shall be programmable through the user interface.
   c. The controller shall be fully programmable to allow up to 8 custom alarm messages to be displayed on the user interface.
   d. A nonadjustable restart delay timer shall be provided to allow the residual voltage of the motor to decay prior to restarting the motor. At least 2 seconds, but no more than 3 seconds, shall elapse between stopping and restarting the pump motor.
   e. A weekly test timer shall be provided as standard. The controller shall have the ability to program the time, date, and frequency of the weekly test. In addition, the controller shall have the capability to display a preventative maintenance message for a service inspection. The message text and frequency of occurrence shall be programmable through the user interface.
   f. A Lamp Test feature shall be included. The user interface shall also have the ability to display the status of the system inputs and outputs.
   g. The controller shall not start the fire pump motor under a single-phase condition. If the motor is already running when a phase loss occurs, the controller shall continue to run the motor, but still display a Phase Failure alarm.

7. The controller shall be manufactured by Firetrol or approved equal.

B. Startup of fire pump controller/transfer switch to be performed by factory trained service technician. Complete startup report to be provided to Owner.

C. Factory trained service technician to demonstrate operation and maintenance of fire pump controller/transfer switch in accordance with Part 3 of this Section.

2.09 JOCKEY PUMP CONTROLLER

A. The auxiliary jockey pump controller shall be factory assembled, wired and tested and specifically designed for controlling a jockey pump. Jockey pump controller shall be UL listed, and shall be of the same manufacturer as the main fire pump controller.

B. The jockey pump controller shall incorporate a magnetic starter, control circuit transformer, main disconnect switch, motor fuse block with fuses, HAND-OFF-AUTOMATIC selector switch and a pressure switch.

C. The pressure switch shall have a range of 15-290 psi (1-20 bars) and have an adjustable differential range of 15-120 psi (1-8.3 bars). The pressure switch shall be of the diaphragm type utilizing snapaction type contacts. The pressure switch shall be mounted inside the jockey pump controller to prevent any unauthorized adjustment and/or accidental damage. The pressure switch shall be directly pipe mounted to a bulkhead pipe coupling without any other supporting members. Field connections shall be made externally at the controller coupling to prevent distortion of the pressure switch element and mechanism.

D. The jockey pump controller shall have a running period timer to prevent too frequent automatic starting of the jockey pump motor. The timer shall be set to keep the motor in operation for at least one minute and interwired with the pressure switch.

E. The disconnect switch shall be mechanically interlocked so that the enclosure door cannot be opened with the handle in the ON position except by a hidden tool operated defeater mechanism. The disconnect switch shall be capable of being padlocked in the OFF position with up to three padlocks for installation and maintenance safety.

F. The minimum enclosure rating shall be NEMA Type 2 (IEC IP11), drip-proof.

G. All pushbuttons, selector switches, pilot lights shall be NEMA Type 12, oiltight. Pilot lights (when specified) shall be transformer type. No pushbuttons or pilot lights shall be mounted on the enclosure door.

H. The control circuit transformer shall be of the molded winding construction type with built-in molded terminals and shall be fuse protected. The fuse shall be built into the transformer.

I. The controller manufacturer, prior to shipment, shall hook up and test the jockey pump controller as a completed assembly. This test shall include, but not be restricted to, each function the controller may be required to perform including manual startstop, automatic start-stop and minimum run timing.

J. The manufacturer shall perform a high potential test of the controller power circuits at not less than two times the rated voltage plus 1000 Volts.

K. Provide leg supports for jockey pump controller if required.

L. Provide auxiliary contacts for pump fail to start, pump overload, pump power failure and phase reversal/phase failure. These alarms shall be interfaced with the Building Automation System (BAS). Manufacturer of jockey pump controller shall coordinate interface requirements with BAS sub-contractor.

M. Startup of jockey pump controller to be performed by factory trained service technician. Complete start-up report to be provided to Owner.

N. Factory trained service technician to demonstrate operation and maintenance of jockey pump controller in accordance with Part 3 of this Section.

2.10 MULTISTAGE, PRESSURE-MAINTENANCE PUMPS, (JOCKEY PUMP)

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

1. A-C Fire Pump Systems; a business of ITT Industries.
2. Grundfos Management A/S; Grundfos Pumps Corporation U.S.A.
3. PACO Pumps; Grundfos Pumps Corporation U.S.A.
4. TACO Incorporated.
5. Or equal as approved by Owner.

B. Description: Factory-assembled and -tested, multistage, barrel-type vertical pump as defined in HI 2.1-2.2 and HI 2.3; designed for surface installation with pump and motor direct coupled and mounted vertically.

C. Pump Construction:

1. Barrel: Stainless steel.
2. Suction and Discharge Chamber: Cast iron with flanged inlet and outlet.
3. Pump Head/Motor Mount: Cast iron.
4. Impellers: Stainless steel, balanced, and keyed to shaft.

5. Pump Shaft: Stainless steel.
6. Seal: Mechanical type with carbon rotating face and silicon-carbide stationary seat.
7. Intermediate Chamber Bearings: Aluminum-oxide ceramic or bronze.
8. Chamber-Base Bearing: Tungsten carbide.
9. O-Rings: EPDM or NBR.

D. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head. Comply with requirements in Division 15 Section "Motors" and the requirements of NFPA-20.

E. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

F. Capacities and Characteristics:

1. Capacity to match existing jockey pump, see Drawings for requirements.

G. Pressure maintenance pump shall meet all requirements of NFPA-20, Standard for the Installation of Stationary Pumps for Fire Protection.

PART 3 - EXECUTION

3.01 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article in Part 1 of this Section.

B. Report test results promptly and in writing.

3.02 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 PIPING APPLICATIONS

A. Do not use welded joints with galvanized steel pipe.

B. Flanges, unions, and transition and special fittings with pressure ratings the same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

C. Standpipes: Use the following:

1. NPS 3 through NPS 6: Standard-weight steel pipe with grooved ends; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

D. Sprinklers: Use the following:

1. Fully concealed sprinklers: match Owner's existing concealed sprinklers.
2. Upright sprinklers: match Owner's existing upright sprinklers.

E. Wet-Pipe Sprinklers: Use the following:

1. NPS 2 and Smaller: Standard-weight steel pipe with threaded ends, cast- or malleable-iron threaded fittings, and threaded joints.
2. NPS 2-1/2 and Larger: Standard-weight steel pipe with grooved ends; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.

3.04 FIRE PUMP CONTROLLER AND TRANSFER SWITCH

A. Install fire pump controller and transfer switch in accordance with manufacturer's installation instructions.

B. Fire Protection Contractor to make all connections between existing fire suppression system and new fire pump controller and transfer switch necessary for proper operation of system.

C. Fire Protection Contractor shall provide and install all accessories necessary for a complete system.

D. Electrical Contractor shall make all electrical connections to fire pump controller and transfer switches.

E. Provide seismic protection of fire pump controller and transfer switch to meet requirements of NFPA-20.

3.05 JOCKEY PUMP CONTROLLER

A. Install jockey pump controller in accordance with manufacturer's installation instructions.

B. Fire Protection Contractor to make all connections between existing fire suppression system and new jockey pump controller necessary for proper operation of system.

C. Fire Protection Contractor shall provide and install all accessories necessary for a complete system.

D. Electrical Contractor shall make all electrical connections to jockey pump controller.

E. Provide seismic protection of jockey pump controller to meet requirements of NFPA-20.

3.06 PRESSURE MAINTENACE PUMP, (JOCKEY PUMP)

A. Install jockey pump in accordance with manufacturer's installation instructions.

B. Fire Protection Contractor to make all connections between existing fire suppression system and new jockey pump necessary for proper operation of system.

C. Fire Protection Contractor shall provide and install all accessories necessary for a complete system.

D. Electrical Contractor shall make all electrical connections to jockey pump.

E. Provide seismic protection of jockey pump to meet requirements of NFPA-20.

F. Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate or to match existing.

G. The pumps shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

H. A check valve shall be installed in the discharge pipe.

I. Indicating butterfly or gate valves shall be installed in such places as needed to make the pump, check valve, and other miscellaneous fittings accessible for repair.

3.07 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Steel-Piping, Grooved Joints: Use Schedule 40 steel pipe with cut or roll-grooved ends and Schedule 30 or thinner steel pipe with roll-grooved ends; steel, grooved-end fittings; and steel, keyed couplings. Assemble joints with couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions. Use gaskets listed for dry-pipe service for dry piping.

C. Dissimilar-Piping-Material Joints: Construct joints using adapters or couplings compatible with both piping materials. Use dielectric fittings if both piping materials are metal. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for dielectric fittings.

3.08 WATER-SUPPLY CONNECTION

A. Connect new sprinkler piping to existing fire sprinkler service.

3.09 PIPING INSTALLATION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation.

B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

C. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

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

F. Install "Inspector's Test Connections" in sprinkler piping, complete with shutoff valve, sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Hangers and Supports: Comply with NFPA 13 for hanger materials. Install according to NFPA 13 for sprinkler piping and to NFPA 14 for standpipes. ***(Refer to Division 15 Section "Hangers and Supports" for additional requirements.)***

I. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage. ***(Refer to Division 15 Section "Vibration and Seismic Control" for additional requirements.)***

J. Install piping with grooved joints according to manufacturer's written instructions. Construct rigid piping joints, unless otherwise indicated.

3.10 SPRINKLER APPLICATIONS

A. General: Use sprinklers according to the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Ceilings: Concealed sprinklers.
3. Sprinkler Finishes: Use sprinklers with the following finishes:

a. Upright, Pendent, and Sidewall Sprinklers: Chrome-plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

3.11 SPRINKLER INSTALLATION

A. Install sprinklers in patterns indicated.

B. Install sprinklers in suspended ceilings in center of acoustical panels and tiles.

C. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical panels.

3.12 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Division 15 Section "Basic Mechanical Materials and Methods."

B. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and in Division 15 Section "Mechanical Identification."

3.13 FIELD QUALITY CONTROL

A. Flush, test, and inspect sprinkler piping according to NFPA 13, "System Acceptance" Chapter.

B. Replace piping system components that do not pass test procedures and retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.14 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers having paint other than factory finish.

3.15 PROTECTION

A. Protect sprinklers from damage until Substantial Completion.

3.16 COMMISSIONING

A. Verify that fire pump controller and automatic transfer switch automatically start/stop fire pump.

B. Verify that automatic transfer switch automatically start/stops emergency generator.

C. Verify that specified tests of piping are complete.

D. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.

E. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.

F. Fill wet-pipe sprinkler piping with water.

G. Energize circuits to electrical equipment and devices.

H. Adjust operating controls and pressure settings.

I. Coordinate with fire alarm tests. Operate as required.

J. Verify that pipe markers are installed.

K. Verify that valve tags are installed.

3.17 DEMONSTRATION

A. Demonstrate to Owner operation of equipment, specialties, and accessories. Review operating and maintenance information with Owner.

B. Schedule demonstration with Owner on 2 occasions, with at least seven days' advance notice.

3.18 ADDITIONAL REQUIREMENTS OF FIRE PROTECTION CONTRACTOR

A. All Contractors and Subcontractors bidding on work in this Section shall be required to review/tour site prior to submitting proposal.

B. Temporary Connections

1. Make temporary piping connections as required to maintain full fire protection services during course of this project both within and outside project areas and whether or not these connections are shown on Drawings.

C. Drawings

1. Drawings are diagrammatic and are intended to convey only general system requirements.
2. Contractor shall be responsible for providing a complete system, which has been approved by Owner, Architect, State/Local Fire Marshal and Owner's Insurance Underwriter, (Owner's Insurance Underwriter to be provided by Owner).

D. Work coordination

1. Fire Protection Contractor shall coordinate his work with General, Electrical, HVAC and Plumbing Contractors and shall make necessary adjustments or changes to facilitate installation of all fire protection equipment in spaces available.

2. HVAC Contractor will provide HVAC piping and sheet metal coordination drawings and will distribute same to Plumbing, Fire Protection and Electrical Contractors for addition of respective information.
3. Fire Protection Contractor shall add to coordination drawings fire protection piping with dimensions above finished floor plus sprinkler head locations.
4. Coordination drawings will only be required to resolve space conflicts within project areas. All coordination issues must be resolved prior to mechanical or electrical construction beginning in that area.
5. Fire Protection Contractor shall coordinate with General Contractor locations of all building structural elements prior to start of construction.

E. Fire Watch

1. When working with an open flame - i.e., soldering, brazing, welding or cutting with a torch - Contractor shall provide fire watch in accordance with requirements of the Municipality and adhere to following requirements:

   a. Fire extinguisher, with current inspection, to be in possession of person performing "Hot Work" at all times.
   b. Provide second person in vicinity of "Hot Work" to perform fire watch.
   c. Contact Owner and Electrical Contractor to disable smoke detectors in immediate vicinity of "Hot Work" procedure. Upon completion of "Hot Work" procedure, smoke detector to be reactivated.
   d. Provide temporary ventilation, as required, for removal of smoke generated by "Hot Work" procedures.

2. As required by OSHA and by accepted standards of safe practice, lock-out/tag-out all equipment required for protection against accidental or inadvertent operation when such operation could cause damage to equipment and/or personnel.
3. Notify General Contractor before instituting any lock-out/tag-out procedure.

F. Access to fire protection installations

1. All fire protection equipment, valves, etc. shall be installed in strict accordance with manufacturer's instructions and installed with clearance for servicing. It is the Fire Protection Contractor's responsibility to insure that systems are installed with adequate clearance for servicing.
2. Drawings are diagrammatic. Fire Protection Contractor shall review equipment installation instructions to insure proper that clearances are maintained.
3. It is the responsibility of the Fire Protection Contractor to insure that access is maintained to fire protection installations. Fire Protection Contractor shall coordinate the work of other trades in the vicinity of fire protection installations requiring servicing to maintain adequate clearances for servicing.
4. Utilize spaces efficiently to maximize accessibility for other installations, maintenance and repairs.
5. Fire Protection Contractor shall notify Architect prior to installing equipment in inaccessible locations.
6. Any work requiring subsequent removal or replacement due to unsatisfactory or defective work, or work that is installed in a manner that is inaccessible for servicing, is the responsibility of the Fire Protection Contractor.
7. Architect and/or Owner shall determine if installations are accessible or inaccessible.

G. Access Panels

1. Panels shall be provided by Fire Protection Contractor for all concealed valves, controls, or any items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Minimum size of panel shall be 12" by 12". Panels shall be complete with identifying labels.
2. Access panels to be constructed and installed to maintain integrity of fire barriers penetrated.
3. Firestop all new and existing fire protection pipe penetrations of existing roofs, floor slabs, 1-hour rated partitions, 2-hour rated partitions and smoke partitions within and enveloping project spaces.
4. At conclusion of firestopping work, inspect firestopping at each newly firestopped penetrations in all roofs, floor slabs and partitions. Each firestopped penetration shall be approved, by signature, by Fire Protection Contractor, Construction Manager and Owner prior to final acceptance of work by Owner. Letter of acceptance by authority having jurisdiction is acceptable.

END OF SECTION 15015

SECTION 15050

BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section including but not limited to:

1. Division 1 Section "Contract Procedures".
2. Division 1 Section "AIA 201 – General Conditions of the Contract for Construction".
3. Division 7 Section "Through-Penetration Firestop Systems".

1.02 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Mechanical demolition.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Supports and anchorages.
11. Commissioning of Mechanical Systems.

1.03 DEFINITIONS

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

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

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

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

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

F. The following are industry abbreviations for plastic materials:

1. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene Propylene Diene Monomer rubber.
2. NBR: Acrylonitrile-Butadiene rubber.

1.04 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. Welding certificates.

1.05 QUALITY ASSURANCE

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

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

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

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. All additional costs required to upgrade electrical services are the responsibility of the Mechanical Sub-Contractor.

1.06 DELIVERY, STORAGE, AND HANDLING

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

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

1.07 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

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

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

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

2.02 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

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

2.03 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

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

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

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

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

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

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

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

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

2.04 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.
c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.

d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

2.05 DIELECTRIC FITTINGS

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

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

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

1. Manufacturers:

a. Perfection Corp.
b. Precision Plumbing Products, Inc.
c. Sioux Chief Manufacturing Co., Inc.
d. Victaulic Co. of America.

2.06 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.07 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.08 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated

PART 3 - EXECUTION

3.01 MECHANICAL DEMOLITION

A. Refer to Division 1 Sections "Contract Procedures" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping shall not be abandoned in place.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ductwork shall not be abandoned in place.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
8. Refer to notes on Plumbing Drawings for additional requirements.

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

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

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

unless deviations to layout are approved on Coordination Drawings.

C. All piping shall be supported from structural steel unless alternate support scenerio is approved in writing by Structural Engineer. Do not support piping from roof decks or floor decks unless approved in writing by Structural Engineer. All auxilliary structural steel required for the support of piping shall be provided and installed by Mechanical Contractor.

D. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

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

G. Install piping to permit valve servicing.

H. Install piping at indicated slopes.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install piping to allow application of insulation.

L. Select system components with pressure rating equal to or greater than system operating pressure.

M. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    d. Bare Piping at Ceiling Penetrations in Finished Spaces One-piece or split-casting, cast-brass type with polished chrome-plated finish.
    e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
    f. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
    g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

2. Existing Piping: Use the following:

    a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
    b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
    c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
    d. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated finish.

e. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
f. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

N. Sleeves are not required for core-drilled holes.

O. Permanent sleeves are not required for holes formed by removable PE sleeves.

P. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

R. Verify final equipment locations for roughing-in.

S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C.

D. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube

end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

F. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

H. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

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

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

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

E. All equipment shall be supported from structural steel unless alternate support scenario is approved in writing by Structural Engineer. Do not support equipment from roof decks or floor decks unless approved in writing by Structural Engineer. All auxiliary structural steel required for the support of equipment shall be provided and installed by Mechanical Contractor.

3.06 PAINTING

A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and

procedures to match original factory finish.

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

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

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

3.08 ADDITIONAL REQUIREMENTS OF MECHANICAL CONTRACTOR

A. The term Mechanical Contractor refers to any Contractor who participates in the installation of building mechanical systems including, but not limited to, fire protection, plumbing, medical gas, heating, ventilating, air conditioning, etc.

B. All Contractors and Subcontractors bidding on work in this Section shall be required to review/tour site prior to submitting proposal.

C. Temporary Connections

1. Make temporary piping connections as required to maintain full use of mechanical services during course of this project both within and outside project areas and whether or not these connections are shown on Drawings.

D. Drawings

1. Drawings are diagrammatic and are intended to convey only general system requirements.
2. Contractor shall be responsible for providing a complete system.

E. Work coordination

1. HVAC Contractor shall coordinate his work with Fire Protection, General, Electrical and Plumbing Contractors and shall make necessary adjustments or changes to facilitate installation of all services in spaces available.
2. HVAC Contractor will provide HVAC sheet metal coordination drawings and will distribute same to Fire Protection and Electrical Contractors for addition of respective information.
3. Fire Protection Contractor shall add to coordination drawings fire protection piping with dimensions above finished floor plus sprinkler head locations.
4. Electrical Contractor shall add locations of conduit runs with dimensions above finished floor and lighting fixtures.
5. Coordination drawings for any building area shall be complete with information from all trades and with all coordination issues resolved prior to mechanical or electrical construction beginning in that area.
6. Mechanical Contractor shall coordinate locations of Plumbing and HVAC piping with the work of other trades. Coordination drawings for Plumbing and HVAC piping are required.
7. Contractors shall coordinate with General Contractor locations of all building structural elements prior to start of construction.

F. Fire Watch

1. When working with an open flame - i.e., soldering, brazing, welding or cutting with a torch - Contractor shall provide fire watch in accordance with requirements of Municipality Fire Department and adhere to following requirements:

   a. Fire extinguisher, with current inspection, to be in possession of person performing "Hot Work" at all times.
   b. Provide second person in vicinity of "Hot Work" to perform fire watch.
   c. Contact Owner and Electrical Contractor to disable smoke detectors in immediate vicinity of "Hot Work" procedure. Upon completion of "Hot Work" procedure, smoke detector to be reactivated.
   d. Provide temporary ventilation, as required, for removal of smoke generated by "Hot Work" procedures.

G. Access to mechanical installations

1. All mechanical equipment, valves, etc. shall be installed in strict accordance with manufacturer's instructions and installed with clearance for servicing. It is the Mechanical Contractor's responsibility to insure that systems are installed with adequate clearance for servicing.
2. Drawings are diagrammatic. Mechanical Contractor shall review equipment installation instructions to insure proper that clearances are maintained.
3. It is the responsibility of the Mechanical Contractor to insure that access is maintained to mechanical installations. Mechanical Contractor shall coordinate the work of other trades in the vicinity of mechanical installations requiring servicing to maintain adequate clearances for servicing.
4. Utilize spaces efficiently to maximize accessibility for other installations, maintenance and repairs.
5. Mechanical Contractor shall notify Architect prior to installing equipment in inaccessible locations.
6. Any work requiring subsequent removal or replacement due to unsatisfactory or defective work, or work that is installed in a manner that is inaccessible for servicing, is the responsibility of the Mechanical Contractor.
7. Architect and/or Owner shall determine if installations are accessible or inaccessible.

H. Access Panels

1. Panels shall be provided by Mechanical Contractor for all concealed valves, controls, or any items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Minimum size of panel shall be 12" by 12". Panels shall be complete with identifying labels.
2. Access panels to be constructed and installed to maintain integrity of fire barriers penetrated.

3.09 COMMISSIONING

A. The Mechanical Contractor shall provide all labor, services and materials required to complete the commissioning of mechanical equipment and systems as described in these Specifications.

1. Refer to the start-up, testing, verification and commissioning requirements under each individual section of these Mechanical Specifications.
2. Refer to Section 01815 for additional requirements.

B. Assist the Architect as required to facilitate and complete the certification of system installations by a Registered Professional Engineer. The services of a Registered Professional Engineer will be provided by others.

3.10 FIRESTOP

A. Ductwork penetrations of fire/smoke partitions to be firestopped using UL rated firestop assemblies.

B. Firestop all new and existing pipe and ductwork penetrations of existing roofs, floor slabs, 1-hour rated partitions, 2-hour rated partitions and smoke partitions within and enveloping project spaces. Using UL rated firestop assemblies.

C. At conclusion of firestopping work, inspect firestopping at each newly firestopped penetrations in all roofs, floor slabs and partitions. Each firestopped penetration shall be approved, by signature, by Mechanical Contractor, Construction Manager and Owner prior to final acceptance of work by Owner.

3.11 UTILITY COMPANY REBATES

A. Mechanical Contractor is responsible for completion of all forms related to utility company rebates.

B. Potential utility company rebates will be determined during construction of project based on utility company rebate programs in place during construction.

C. All utility company rebates will be paid to Owner.

END OF SECTION 15050

SECTION 15055

MOTORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration and Seismic Controls" for mounting motors and vibration isolation and seismic-control devices.
2. Division 15 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.03 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.04 SUBMITTALS

A. Test Reports: Written reports specified in Parts 2 and 3.

B. Operation and Maintenance Data: For motors to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.06 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:

a. Magnetic controllers.
b. Multispeed controllers.
c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section.

PART 2 - PRODUCTS

2.01 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.
2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.02 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and Larger: Three phase.

B. Motors Smaller Than 1/2 HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency:

1. Premium efficiency.
2. All electric motors 1.0 hp and larger shall meet efficiency requirements of Owner's electric utility company and Northeast Premium Efficiency Motor Initiative (NPEMI).
3. NPEMI NEMA nominal efficiency requirements for open drip-proof, 1800 rpm motors.

a. 1.0 hp: 85.5%
b. 1.5 hp: 86.5%

c. 2.0 hp: 86.5%
d. 3.0 hp: 89.5%
e. 5.0 hp: 89.5%
f. 7.5 hp: 91.0%
g. 10.0 hp: 91.7%
h. 15.0 hp: 93.0%
i. 20.0 hp: 93.0%
j. 25.0 hp: 93.6%
k. 30.0 hp: 94.1%
l. 40.0 hp: 94.1%
m. 50.0 hp: 94.5%
n. 60.0 hp: 95.0%
o. 75.0 hp: 95.0%
p. 100.0 hp: 95.4%
q. 125.0 hp: 95.4%
r. 150.0 hp: 95.8%

C. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.05 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

E. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 3.

C. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.03 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
2. Test interlocks and control features for proper operation.
3. Verify that current in each phase is within nameplate rating.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Verify bearing lubrication.
4. Verify proper motor rotation.
5. Test Reports: Prepare a written report to record the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Test results that do not comply with requirements and corrective action taken to achieve compliance.

3.04 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.05 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 15055

SECTION 15060

HANGERS AND SUPPORTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

B. Related Sections include the following:

1. Division 5 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
2. Division 13 Sections on fire-suppression piping for fire-suppression pipe hangers.
3. Division 15 Section "Mechanical Vibration Controls and Seismic Restraints" for vibration isolation and seismic restraint devices.

1.03 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.04 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.05 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports, channel supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details. Mechanical Contractor is responsible for all costs associated with approval of multiple piping supports, channel supports and trapeze hangers.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.06 QUALITY ASSURANCE

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

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.
2. Cost of Engineering of multiple pipe supports is the responsibility of the contractor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Empire Tool & Manufacturing Co., Inc.
d. Grinnell Corp.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Grinnell Corp.; Power-Strut Unit.
c. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. PHS Industries, Inc.
d. Pipe Shields, Inc.
e. Rilco Manufacturing Co., Inc.
f. Value Engineered Products, Inc.

4. Powder-Actuated Fastener Systems:

a. Gunnebo Fastening Corp.
b. Hilti, Inc.
c. ITW Ramset/Red Head.
d. Masterset Fastening Systems, Inc.

2.02 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For hangers and supports that will not have field-applied finish.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.
3. All hangers and supports that are not furnished with specified metallic or non-metallic coatings shall be field painted.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, bare metal surfaces shall not be used.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
2. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
3. Material for Cold Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
4. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
5. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
6. For Clevis: Insert and shield cover lower 180 degrees of pipe.
7. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

D. All pipe hangers and field fabricated supports to be painted black or to be galvanized steel.

E. All hanger rod to be galvanized steel.

F. All hangers used to support insulated piping systems shall be equipped with 180 degree insulation shield install between finished insulation and pipe hanger.

2.03 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 and larger or for suspension of non-insulated or insulated piping with horizontal movement.
2. Adjustable Band Hangers (MSS Type 9): For suspension of sprinkler pipes, NPS 1/2 to NPS 8.
3. Pipe Saddle Supports (MSS Type 36): For support of pipes, with steel pipe base stanchion support and cast-iron floor flange.
4. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
5. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
6. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 2 1/2 and larger, from two rods if longitudinal movement caused by expansion and contraction might occur.
7. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 and larger, from single rod if horizontal movement caused by expansion and contraction might occur.
8. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 and larger, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
9. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 and larger, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
10. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 and larger, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
11. Vee Bottom Clevis Hanger (MSS SP-69 & SP-58 Type 1) with continuous Plastic Pipe Support Channel for continuous support of polypropylene piping systems.

D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 and larger.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 and larger, if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weld-less Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

3.02 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Submit shop drawings for approval prior to installation.
2. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Submit shop drawings for approval prior to installation.
2. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
3. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. All piping shall be supported from structural steel unless alternate support scenario is approved in writing by Structural Engineer. Do not support piping from roof decks or floor decks unless approved in writing by Structural Engineer. All auxiliary structural steel required for the support of piping shall be provided and installed by Mechanical Contractor.

E. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

F. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

G. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

L. All piping within 50 feet of pumps or air handling units shall be supported using vibration isolators. Where required, isolators to be seismic rated.

M. Insulated Piping: Comply with the following:

1. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.04 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

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

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

3.05 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.06 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15060

SECTION 15071

MECHANICAL VIBRATION AND SEISMIC CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 DESCRIPTION

A. General

1. This dual-purpose section provides vibration isolation and seismic restraints for the following "equipment":

a. Fire Suppression Piping
b. HVAC Piping
c. Fuel Oil Pumpset
d. Unit Heaters
e. Fans (All types)
f. Ductwork

B. Intent

1. It is the intent of the seismic restraint portion of this specification to provide seismic restraints for non-structural building components. Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component's center of gravity.
2. Each and every support attachment to the structure of equipment that meets the requirements of this specification must be positive.
3. The work in this section includes the following:

a. Vibration isolation for equipment.
b. Seismic restraints for equipment.
c. Certification of seismic restraint designs and installation supervision.
d. Piping flexible connectors.

C. Definitions

1. The term EQUIPMENT will be used throughout this specification and it includes ALL non-structural components within the facility and/or serving this facility, such as equipment located in outbuildings or outside of the main structure on the ground. Equipment buried underground are excluded but entry of services through the foundation walls are included. Equipment referred to above is a partial list of equipment for reference. (Equipment not listed is still included in this specification)

D. Life safety systems defined

1. All systems involved with fire protection.
2. All gas piping, hazardous material systems, and high pressure steam piping.
3. All medical and life support systems.
4. All systems involved with and/or connected to emergency power supply.
5. Any component or system whose failure could impair the continued operation of the facility.

E. Positive Attachment

1. Positive attachment is defined as a support location with a cast-in or wedge type expansion anchor, a double-sided beam clamp loaded perpendicular to a beam or a welded or through bolted connection to the structure.

F. Transverse Bracing

1. Restraint(s) applied to limit motion perpendicular or angular to the centerline of the pipe or duct.

G. Longitudinal Bracing

1. Restraint(s) applied to limit motion along the centerline of pipe or duct.

1.03 OEM EQUIPMENT ISOLATION PACKAGES FOR INTERIOR EQUIPMENT

A. Internal and/or External Systems

1. The substitution of internally or externally isolated and restrained equipment by the equipment manufacturer in lieu of the isolation and restraints specified in this section is acceptable provided all conditions of this section are met. The equipment manufacturer shall provide a letter of guarantee from their Engineering Department stamped and certified per the section on Seismic Restraints and Analysis stating that the seismic restraints are in full compliance with these specifications. Letters from field offices or representatives are unacceptable.
2. All costs for converting to the specified vibration isolation and/or restraints shall be borne by the equipment manufacturer in the event of non-compliance with the proceeding.
3. In the event that the equipment is internally or externally isolated and restrained by the equipment manufacturer, the entire unit assembly must be seismically attached to the structure. This attachment and certification thereof shall be by this section.
4. When roof mounted air moving equipment is specified to be mounted on spring curbs, rails or bases, substitution of internal fan isolators does NOT meet the provisions of this section.

1.04 SUBMITTAL DATA REQUIREMENTS

A. Submittals

1. Provide catalog cuts or data sheets on specific vibration isolators and restraints to be utilized, detailing compliance with the specification. Reference "TYPE" as per "PRODUCTS" section of this specification.

2. Provide an itemized list of all isolated and non-isolated equipment including detailed schedules showing isolator and seismic restraints proposed for each piece of equipment, referencing material and seismic calculation drawing numbers.

B. Shop Drawings

1. Show base or stand construction; include dimensions, structural member sizes and support point locations.
2. Indicate isolation devices selected with complete dimensional and deflection data.

3. Calculate thrust for fan heads, axial and centrifugal fans to determine whether thrust restraints are required. (See EQUIPMENT INSTALLATION)
4. When walls and slabs are used as seismic restraint locations, details of acceptable methods for pipe and duct must be included.
5. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
6. Coordinated or contract drawings shall be marked-up with the specific locations and types of restraints shown for pipe and duct. Rod bracing requirements and assigned load at each and every restraint location shall be clearly delineated, "worst case" analyses are not acceptable. Any and all tributary loads shall be considered for proper restraint sizing.
7. For ceiling suspended equipment, design restraints for a minimum installation angle of 30 degrees from vertical. Indicate maximum installation angle allowed for restraint system as well as braced and unbraced rod lengths at 30, 45, 60, 75 and 90 degrees from vertical, to determine when rod bracing is required.

C. Seismic Certification and Analysis

1. Seismic restraint calculations must be provided for all connections of equipment to the structure. All performance of products (such as; strut, cable, anchors, clips, etc.) associated with restraints must be supported with manufacturer's data sheets or certified calculations.
2. For equipment mounted outside of the building both the seismic acceleration and wind loads shall be calculated, the highest load shall be utilized for the design of the attachment of supports.
3. Analyses must indicate calculated dead loads, derived loads and materials utilized for connections to equipment and structure and detail anchoring methods, bolt diameter, embedment and weld length.
4. An in force, Errors and Omissions insurance certificate must accompany submittals. Manufacturer's product liability insurance certificates are NOT acceptable.

1.05 MANUFACTURER'S RESPONSIBILITY

A. Manufacturer of vibration and seismic control equipment shall have the following responsibilities:

1. Determine vibration isolation and seismic restraint sizes and locations.
2. Provide vibration isolation and seismic restraints as specified.
3. Provide installation instructions, drawings and field supervision to insure proper installation and performance of systems.
4. Provide copies of all calculations stamped by a Professional Engineer licensed in the State that the project is located.

1.06 RELATED WORK

A. Housekeeping Pads

1. Housekeeping pad attachment to structure design shall be by the project structural engineer. Material and labor required for attachment and construction shall be by the concrete section contractor or as otherwise specified.
2. Housekeeping pads shall be coordinated with the Seismic Restraint Supplier and sized to provide a minimum edge distance of 13 bolt diameters of clearance all around the outermost anchor bolt to allow for the use of full anchor ratings.

B. Supplementary Support Steel

1. Contractor shall supply supplementary support steel and connections for all equipment, piping, ductwork, etc. as required or specified.
2. Where support for equipment requires stands, bases, rails, etc. these devices shall be

designed and fabricated by Seismic Restraint Supplier to ensure the seismic capability of the entire installation.

C. Attachments

1. Contractor shall provide restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, riser guides and anchors, etc. as directed by the Seismic Restraint Supplier.

1.07 CODE REQUIREMENTS

A. Seismic restraints as described herein shall be provided in accordance with International Building Code, 2006 Edition, Seismic Use Group IV, Site Class D, S_1=0.08, S_s=0.32, Seismic Design Category C.

PART 2 - PRODUCTS

2.01 DESCRIPTION

A. Devices

1. All vibration isolation and seismic devices described in this section shall be the product of a single supplier. NAI (Novia Associates, Inc.) is the preferred supplier. Products manufactured by Vibration Eliminator or Amber Booth may be acceptable provided their systems strictly comply with intent and submittal requirements of these specifications.

2.02 SEISMIC RESTRAINTS AND VIBRATION ISOLATION TYPES

A. General

1. Corrosion protection for outdoor applications shall be as follows:

a. Hardware shall be cadmium or zinc plated, all other metal parts shall be hot dipped galvanized or zinc electroplated.

2. Springs used in isolator products:

a. Shall be cadmium plated, zinc electroplated, or powder coated.
b. Shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection, reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.
c. Shall be provided with minimum 1/4" thick neoprene cups or base pad.
d. When used in hangers, springs shall be capable of 30 degree misalignment between the rod attachment to structure and the connection to the supported equipment.
e. Welding of springs to isolator housing, base plates, etc. is strictly prohibited.

3. All hangers shall be capable of withstanding three times the rated load without failure.
4. All seismic restraint devices:

a. Shall maintain the equipment in a captive position when subjected to the design "g" force as determined by the seismic certification and calculations as described in the "SUBMITTAL DATA REQUIREMENTS" section of these specifications and not short circuit isolation device during normal operating conditions.
b. Shall have provisions for bolting to the structure.

B. Seismic Restraint Types

1. TYPE I: Where required, each corner or side of equipment base shall incorporate a seismic restraint snubber having an all directional limit stop. Restraints shall be fabricated of plate, structural members or square metal tubing.

   a. Model "SS" as manufactured by NAI.

2. TYPE II: Restraints for suspended systems.

   a. Vibration isolated systems shall be braced with multiple 7 x 19 galvanized steel cables with approved attachment devices (such as thimbles and wire rope clips) to equipment and structure.
   b. Non-isolated systems shall be braced with structural steel strut or cable with approved attachment devices to equipment and structure.
   c. Steel angles (by contractor) shall be provided to prevent rod bending of hung equipment where indicated by the Seismic Restraint Supplier's submittals. Each steel angle shall be attached to the rods with a minimum of three Seismic Rod Clamps, Model "SRC" by NAI at each restraint location. Welding of support rods to angles is not acceptable.

3. TYPE III: Rigid attachments to structure utilizing wedge type expansion anchors for bolting and steel plates, either cast-in or anchored with wedge type expansion bolts, for welding. Powder shots are not acceptable. Concrete anchor bolt spacing shall be in accordance with anchor manufacturer's published standards. Welding or through bolting are acceptable alternate attachment methods.

C. Vibration Isolator Types

1. TYPE A: Spring Isolator - Free Standing

   a. Adjustment bolt counter bored and tapped with locking cap screw.
   b. Model "SM" as manufactured by NAI.

2. TYPE B: Spring Isolator - Restrained

   a. Formed or welded steel housing with integral restraining bolts with elastomeric bushings preventing metal-to-metal contact. Provide internal spring adjusting nut or bolt and neoprene base pad.
   b. Model "RSM" as manufactured by NAI.

3. TYPE C: Spring Hanger Isolator

   a. A spring located inside a four sided steel box.
   b. Model "SH" as manufactured by NAI.

4. TYPE D: Double Deflection Neoprene

   a. Molded 1-1/4" minimum thickness neoprene element, mounted in a steel frame.
   b. Mountings shall be fabricated to resist wind or seismic forces.
   c. Model "RNM" as manufactured by NAI.

5. TYPE E: Elastomer Hanger Isolator

   a. Molded 1-1/4" minimum thickness neoprene element, located inside a four sided steel box.
   b. Model "NH" as manufactured by NAI.

6. TYPE F: Combination Spring/Elastomer Hanger Isolator

   a. Molded 1-1/4" minimum thickness neoprene element in series with the spring, located inside a four sided steel box.
   b. Model "SNH" as manufactured by NAI.

7. TYPE I: Thrust Restraints

   a. A spring shall be combined with steel angles, backup plates, threaded rod, washers, and nuts to produce a pair of devices capable of limiting thrust movement of air moving equipment to 1/4". Restraints shall be easily converted in the field from a compression type to tension type. Unit shall be factory precompressed.
   b. Model "TR" as manufactured by NAI.

8. TYPE L: Elastomer Isolator

   a. Double deflection neoprene compression mountings.
   b. Non-skid top and bottom surfaces with drilled tie-down bolt holes. Threaded bolting sleeves shall be embedded in the isolator.
   c. Model "FMD" by NAI.

2.03 EQUIPMENT BASES & CURBS

A. General

1. All non galvanized materials shall be prime paint finished.
2. Review equipment sections of these specifications and contract drawings for additional requirements.
3. Operating height for supports shall be as shown on the drawings.
4. Provide pre-drilled holes on all supports for attachment to the building structure.

B. Types

1. TYPE B-1: Integral Structural Steel Base

   a. Constructed of structural members as required to support equipment with a maximum deflection of L/360.
   b. Where required, height saving brackets shall be used to maintain 1" operating clearance under base.
   c. Model "SB" as manufactured by NAI.

2.04 FLEXIBLE CONNECTORS

A. TYPE FC-1: Spherical EPDM Connector

1. Sizes 2 inch and larger shall have two spheres reinforced with an external ring between spheres. Bolted-on strap type reinforcing is not acceptable. Sizes 16 inch to 24 inch may be single sphere.
2. Threaded one piece bolted flange assemblies with female threaded ends for sizes 3/4 inch to 1-1/2 inches.
3. Rated at 250 psi up to 1700 degrees F, with a uniform drop in allowable pressure to 170 psi at 2500 degrees F for sizes through 14 inches. 16 through 24 inch single sphere minimum ratings are 180 psi at 1700 degrees F and 130 psi at 2500 degrees F.
4. Connectors shall be installed in piping gaps equal to the length of the connector under pressure.

5. Control rods are required in unanchored installations where the installation exceeds the pressure limitation without control rods. Provide 1/2 inch thick Neoprene washer bushings large enough in diameter to take the thrust at 1,000 psi maximum on the washer area.
6. Connectors bolted to Victaulic type coupling or gate, butterfly or check valves to have a minimum 5/8 inch flange spacer (by others) installed between the connector and the coupling flange. Connectors must mate to a flat-faced flange in all instances.
7. Model EU302 manufactured by Unisource.

B. TYPE FC-2: Flexible Stainless Steel Hose

1. Stainless steel hose and braid rated with 3:1 safety factor.
2. 2 inch diameter and smaller with male nipples, 2-1/2 inch and larger with fixed flat faced steel flanges.

    a. Lengths shall be: 9 inches for 2-1/2 to 4 inch, 11 inches for 5 and 6 inch, 12 inches for 8 inch, 13 inches for 10 inch, and 14 inches for 12 to 16 inch.
    b. Model UPCS as manufactured by Unisource.

C. TYPE FC-3: 18" Long Unbraided Exhaust Hose

1. Low pressure stainless steel annularly corrugated with flanged ends.
2. Maximum temperature of 1500 degrees F.

D. TYPE FC-4: Wire Braid Reinforced Flexible Metal Hose

1. Stainless steel braided metal hose with copper tube ends. Rated with a minimum 3:1 safety factor. (Minimum 150 PSI)
2. Braid shall be hydro-formed utilizing a close-pitch omega shape configuration certified to meet ISO 10380 for minimum life cycle and recognized by UL (file number: SA9774).
3. Connectors shall be cleaned, dried, and sealed in bags for use on refrigeration and air conditioning systems.
4. Model UFV - Ultra-Vibe manufactured by Unisource.

PART 3 - EXECUTION

3.01 GENERAL

A. Vibration Isolation and seismic restraint systems must be installed in strict accordance with the manufacturer's submittal data.

B. Vibration isolators shall not cause any change of position of equipment resulting in stress on equipment connections.

C. Hanger isolators shall be installed plumb so as not to short-circuit the hanger box and hung as close as possible to the structure. (Without touching)

3.02 EQUIPMENT INSTALLATION

A. Equipment shall be isolated as follows and as indicated in the Vibration Isolation, Bases & Curbs Schedule on the contract drawings.

B. Additional Requirements:

1. The minimum operating clearance under all bases shall be 1 inch.
2. All bases shall be placed in position and supported temporarily by blocks or shims prior to the installation of the equipment, isolators, and restraints.

3. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free in all directions.
4. After the entire installation is complete and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators.
5. Products supplied with shims, (spacers) are provided to maintain operating height. These shims must not be removed until the unit is set on the isolators and under full operational load. After adjustment of the isolators, the shims are to be removed (by hand) and discarded.
6. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.
7. Install equipment with flexibility in wiring.
8. Housekeeping pads for equipment in this section must be properly doweled or bolted, using wedge type expansion bolts to meet the acceleration criteria. Anchor equipment or isolators to housekeeping pads, see RELATED WORK section of these specifications.
9. Equipment with less than 1/3 H.P. is excluded from vibration requirements. (Seismic requirements still apply)

3.03 PIPING ISOLATION INSTALLATION

A. All piping in mechanical equipment room(s) connected to rotating or reciprocating equipment and all roof mounted piping within 50 feet of rotating or reciprocating equipment shall be isolated as follows:

1. Water and steam piping.

   a. Water piping 1-1/4 to 2 inch and all steam piping larger than 1 inch shall be supported with TYPE E or L isolators with 1/4 inch deflection.
   b. Water pipe larger than 2 inch shall be supported with TYPE A or F isolators with 3/4 inch deflection.

2. Control air piping, compressed air and vacuum piping within 50 feet of pump or compressor shall be supported with TYPE E or L isolators with ¼ inch deflection.
3. Emergency generator exhaust shall be supported with TYPE A or C isolators with 3/4 inch deflection (all neoprene components shall be omitted).

3.04 DUCTWORK ISOLATION INSTALLATION

A. All ductwork over four square feet face area located within 50 feet from air moving equipment shall be supported with TYPE A or C isolators with 3/4 inch deflection.

3.05 FLEXIBLE CONNECTOR INSTALLATION

A. All connectors shall be installed on the equipment side of shutoff valves; horizontal and parallel to equipment shafts whenever possible. Piping shall be supported and/or anchored to resist pipe movement beyond the allowable movement of the flexible connector. Installations must include check valves and/or other design and installation precautions to reduce the threat to life safety when subjected to the specified seismic accelerations.

B. Provide flexible connections for all piping connected to isolated curb mounted roof top equipment.

C. Install TYPE FC-1 flexible connectors at all connections of pipe to externally isolated equipment.

D. Install TYPE FC-3 flexible connectors at all connections at Emergency Generator exhaust piping. Coordinate end fittings with generator manufacturer.

E. Install TYPE FC-2 or 4 connectors only at locations which exceed temperature limitations of FC-1 or service requires stainless steel or bronze construction flex. (Such as; spaces without floor drains, or pipes carrying gas, fuel oil, steam or Freon)

F. Install TYPE FC-5 Flexible V-Loops as shown on the drawings.

1. At least one pipe guide should be positioned within four pipe diameters on each side of the loop.

3.06 SEISMIC RESTRAINT INSTALLATION

A. Floor or roof mounted equipment shall be snubbed, anchored, bolted or welded to the structure. Calculations that determine that isolated equipment movement may be less than the operating clearance of snubbers (restraints) do not preclude the need for snubbers. Equipment must be positively attached to the structure.

B. Suspended equipment shall be two or four point independently braced with TYPE II restraints. Install cable braces taught for non-isolated equipment and slack with ½ inch cable deflection for isolated equipment. Rod bracing shall be installed as per approved submittals and shop drawings.

C. Horizontally suspended pipe and duct shall use RESTRAINT TYPE II. Maximum spacing of seismic bracing shall be as per TABLE A at the end of this section.

1. For all trapeze-supported piping, the individual pipes must be attached to the trapeze support at the designated restraint locations.

D. For overhead supported equipment, over stress of the building structure must not occur. Bracing may occur from; flanges of structural beams, upper truss chords in bar joists or cast in place inserts or drilled and shielded inserts in concrete structures.

1. Any individual calculated seismic load placed on the building structure (other than concrete slabs) that is greater than 2,000 lb must be reviewed by the project Structural Engineer for approval.

E. Pipe Risers

1. Where pipes pass through cored holes, holes must be packed with resilient material or fire stop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required at these locations.
2. Constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of the slab attached in a seismically approved manner for vertical restraint.
3. Constant temperature pipe risers in pipe shafts require structural steel attached in a seismically approved manner at each floor level and a riser clamp at each floor level on top of, and fastened to the structural steel. The riser clamp and structural steel must be capable of withstanding all static and seismic loads.
4. Variable temperature risers through cored holes require guides and anchors installed to meet both thermal expansion and seismic acceleration criteria.
5. Variable temperature risers in pipe shafts require guides and anchors installed on structural steel to meet both thermal expansion and seismic acceleration criteria.

F. Fixtures such as radiant panels and diffusers shall be attached to lay-in ceilings with a minimum of four Teks screws or other means of positive attachment to the T- bar ceiling structure.

G. Non-isolated floor mounted equipment and tanks shall use RESTRAINT TYPE I or III.

H. Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE II shall be located above the unit's center of gravity to suitably resist "g" forces specified.

1. Vertically mounted tanks, up-blast tubular centrifugal fans, or similar equipment may require this additional restraint.

I. A rigid piping or duct system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and roof; solid concrete wall and a metal deck with lightweight concrete fill, pipes and duct that cross a building expansion joint.

J. Exemptions from seismic requirements on non life safety equipment:

1. General

a. In Seismic Use Group IV, all components are considered Ip = 1.5. See life safety section for exceptions.

K. Exemptions from seismic requirements on life safety equipment.

1. General

a. Ceiling hung equipment weighing less than 75 lbs that is rigidly attached to ductwork.
b. Components positively attached to the finish ceiling shall be considered part of the ceiling grid and do not require individual seismic restraints.
c. Curb mounted equipment with curb area (O.D.) less than nine square feet are excluded unless specifically detailed in the schedules or drawings.

2. Piping exemptions

a. All life safety or hazardous piping that is less than 2 inch nominal diameter.
b. All clevis or single level trapeze supported piping suspended by hangers with positive attachment to the structure that are less than 12 inches in length as measured from the top of the pipe to the point of attachment to the structure. If any hanger in the run exceeds the 12 inch limit, seismic bracing is required for the run.

3. Duct exemptions

a. Rectangular, square, and flat oval ducts less than four square feet in cross sectional area.

3.07 INSPECTION

A. If in the opinion of the project engineer the seismic restraint installation does not meet with the project requirements, an outside consultant will be retained to inspect, verify and submit corrective measures to be taken. The consultant's fees and all work associated with such a review shall be borne by the contractor.

3.08 FIELD QUALITY CONTROL

A. Testing: Manufacturer shall engage a qualified individual to perform the following field quality-control testing.

B. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.
2. Isolator deflection.

3. Snubber minimum clearances.
4. Certification that all required devices are installed.
5. Certification that all required devices are properly installed.

C. Submit report to Architect after Field Quality Control is completed.

3.09 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

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

C. Attach thrust limits at centerline of thrust and adjust to a maximum of ¼ inch movement during start and stop.

D. Adjust air spring leveling mechanism.

E. Adjust active height of spring isolators.

F. Adjust snubbers according to manufacturer's written recommendations.

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

H. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.10 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1 Section "Contract Procedures."

B. Engage a factory-authorized service representative to review project prior to occupancy by Owner. Factory-authorized service representative to confirm that all seismic restraint devices have been installed and that the seismic restraint devices have been installed in accordance with all manufacturers' installation requirements.

TABLE A SEISMIC BRACING TABLE

EQUIPMENT	TRANSVERSE	LONGITUDINAL
DUCT	30 Feet	60 Feet
PIPE	40 Feet	80 Feet
STACKS	30 Feet	60 Feet

END OF SECTION 15071

SECTION 15075

MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Equipment markers.
3. Equipment signs.
4. Access panel and door markers.
5. Pipe markers.
6. Duct markers.
7. Valve tags.
8. Valve schedules.
9. Warning tags.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.04 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.05 COORDINATION

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

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Brady.

B. Seton Nameplate Company.

2.02 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number, and serial number.
b. Capacity, operating and power characteristics, and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.

C. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.03 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Pressure sensitive, adhesive backed, permanent-type, preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms as required by Owner and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Full-band pipe markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

2.04 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Paint markers on all new and existing ductwork in project area. Include air system designation, direction of air flow and duct service (such as supply, return, and exhaust).

2.05 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme provided by Owner. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch- thick brass.
2. Valve-Tag Fasteners: Brass chain.

2.06 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.07 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.01 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.02 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel oil day tank, fuel oil transfer pump, and similar motor-driven units.
2. Fans, blowers.
3. Unit heaters.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

    a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
    b. Fire department hose valves and hose stations.
    c. Meters, gages, thermometers, and similar units.
    d. Tanks and pressure vessels.
    e. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.03 PIPING IDENTIFICATION

A. Do not use pipe markers and tapes for bare pipes conveying fluids at temperatures of 125°F or higher.

B. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.

C. Locate pipe markers and color bands on all piping including piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations, above all ceilings; on all concealed piping locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 15 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On all piping concealed in walls.
8. A minimum of 1 pipe marker shall be installed on piping above acoustical tile ceilings in each room.

D. For medical gas services, pipe markers shall include service of each piping system, normal operating pressure and directional flow arrows.

E. All piping in project area, new and existing shall be labeled.

3.04 DUCT IDENTIFICATION

A. Paint duct markers on air ducts in the following color codes:

1. Blue: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
2. Letter Size: Minimum 2 inch for name of units if viewing distance is less than 24 inches, 2-1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

B. Locate markers near points where ducts enter into concealed spaces, in duct shafts and at maximum intervals of 15 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.05 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; plumbing fixture supply stops; faucets; convenience and lawn-watering hose connections. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

a. All: 2 inches, round.

2. Valve-Tag Color:

a. All valve tags to have brass or stainless steel finish.

3. Letter Color:

a. Letter color to be black.

C. All valves, new and existing in project areas to be tagged.

3.06 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.07 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.08 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.09 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 15075

SECTION 15081

DUCT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes rigid, semi-rigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
2. Division 15 Section "Pipe Insulation" for insulation for piping systems.

1.03 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Removable insulation sections at access panels.
2. Application of field-applied jackets.
3. Applications at linkages for control devices.

C. Samples: For each type of insulation on roof and field-applied jacket. Identify each Sample, describing product and intended use. Submit 12-inch- square sections of each sample material.

1. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

D. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.06 COORDINATION

A. Coordinate clearance requirements with duct Installer for insulation application.

1.07 SCHEDULING

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

B. Mineral-Fiber Board Insulation:

a. CertainTeed Corp.; Commercial Board.
b. Fibrex Insulations Inc.; FBX 1200 Series.
c. Johns Manville; 800 Series Spin-Glas.
d. Knauf Insulation; Insulation Board.
e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.

2.02 INSULATION MATERIALS

A. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied jacket with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film..

2.03 ACCESSORIES AND ATTACHMENTS

A. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface.

2.04 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

L. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

N. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.

1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

O. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, including fire-rated walls and partitions without fire dampers.

P. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

3.04 MINERAL-FIBER INSULATION APPLICATION

A. Board Applications for Ducts and Plenums: Secure board insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Space anchor pins as follows:

   a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
   c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.

4. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.05 DUCT SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

C. Insulate the following plenums and duct systems:

1. Indoor louver duct plenums.
2. Indoor outside-air ductwork.

D. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Underground ductwork.
2. Metal ducts with duct liner.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
5. Flexible connectors.
6. Vibration-control devices.
7. Testing agency labels and stamps.
8. Nameplates and data plates.
9. Access panels and doors in air-distribution systems.

3.06 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Rectangular louver plenums and outside air/transfer air ductwork. Rectangular outside air/transfer air ductwork in Mechanical Rooms. Rectangular outside air/transfer air ductwork exposed to view.

1. Material: Rigid, Mineral-fiber duct-board.
2. Thickness and R-value: 2 inches, R=5.
3. Number of Layers: One.
4. Field-Applied Jacket: Foil and paper.
5. Vapor Retarder Required: Yes.

3.7 INDOOR AIR QUALITY PROTECTION

A. Mineral fiber insulation edges, ends, and joints shall be positively and permanently sealed with insulation covering to preclude the release of insulation particles to the indoor environment.

B. Insulation of all types shall be applied to exterior surfaces of ducts and plenums only. No insulation shall be applied to interior surfaces of any ducts or plenums.

END OF SECTION 15081

SECTION 15083

PIPE INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
2. Division 15 Section "Duct Insulation" for insulation for ducts and plenums.
3. Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.03 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.
2. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
3. Removable insulation at piping specialties and equipment connections.
4. Application of field-applied jackets.

C. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

D. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.04 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.06 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for insulation application.

1.07 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Calcium Silicate:

   a. Industrial Insulation Group, LLC
   b. Einsulation

2. Mineral-Fiber Insulation:

   a. CertainTeed Manson.
   b. Knauf FiberGlass GmbH.
   c. Owens-Corning Fiberglas Corp.
   d. Schuller International, Inc.

3. Cellular-Glass Insulation:

   a. Pittsburgh-Corning Corp.

4. Closed-Cell Phenolic-Foam Insulation:

   a. Kooltherm Insulation Products, Ltd.

2.02 INSULATION MATERIALS

A. Calcium Silicate: Inorganic, noncombustible, asbestos free, hydrous calcium silicate for use on systems operating from 80°F to 1200°F.

1. Preformed Pipe Sections: Comply with ASTM C 533, Type 1.
2. Prefabricated Fitting Covers: Comply with ASTM c 450 and ASTM C 585 for dimensions use in preforming insulation to cover valves, elbows, tees, and flanges.
3. Adhesive: Fibrous, sodium silicate based adhesive with a service temperature range of 50°F to 800°F.

B. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

a. Class 1, Grade A for bonding glass cloth and tape to un-faced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to un-faced glass-fiber insulation.
b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
5. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
6. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

C. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.
2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

D. Closed-Cell Phenolic-Foam Insulation: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.03 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil- thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45 and 90 degree, short and long radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: As recommended by insulation material manufacturer.

D. Removable reusable insulation covers for hot equipment.

1. Fiberglass cloth outer cover, 1inch thick fiberglass insulating matt and stainless steel mesh inner cover. All materials shall withstand temperatures to 400°F without deterioration or decomposition.
2. Covers self-extinguishing in conformance with UL-492 and producing no toxic or corrosive byproducts when exposed to flames. Outer covers water resilient and weigh no less than 16 oz/sq yd.
3. Fiberglass matts shall have maximum thermal conductivity of 0.33 Btu-in/hr-sq ft-°F at 300°F.
4. Covers neatly formed with no exposed fiberglass matt.
5. Fasteners shall hold covers securely to items being insulated and in manner to minimize heat losses. Only valve stems, valve hand-wheels and valve operators shall extend outside reusable covers. Valve bonnets shall be covered. Fasteners shall be easily and simply disassembled and reassembled without special tools and without damage to insulation systems. When wire is used for fastening, wire shall be stainless steel.

E. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.

1. Finish and Thickness: Stucco-embossed finish, 0.016 inch thick.
2. Moisture Barrier: 1-mil thick, heat bonded polyethylene and kraft paper.
3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.04 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..

1. Tape Width: 4 inches.

B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch thick.

2.05 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.03 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

   a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

S. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.04 CALCIUM SILICATE INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure single layer insulation with stainless steel bands at 12 inch intervals and tighten bands without deforming insulation material.
2. Install two layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12 inch intervals. Secure outer layer with stainless steel bands at 12 inch intervals.
3. Apply a skim coat of mineral fiber, hydraulic setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Apply insulation on pipe fittings and elbows as follows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacture's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

3.05 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.
4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Install removable reusable insulation covers at valves, strainers humidifier bodies, steam traps and other hot equipment requiring periodic service. Install on all devices in mechanical spaces and above ceilings.
2. Apply insulation to flanges as specified for flange insulation application.
3. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.06 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. Cover insulation with field applied aluminum jacket.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.
4. Install field applied aluminum fitting covers.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with field applied aluminum fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
2. Apply insulation to flanges as specified for flange insulation application.
3. Cover valve bodies with field applied aluminum fitting covers.

3.07 CLOSED-CELL PHENOLIC-FOAM INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams, and end joints with vapor-retarder mastic.
3. For insulation with factory applied jackets, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded sections of insulation are not available, apply mitered sections of phenolic-foam insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard PVC fitting covers.
4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded sections of insulation are not available, apply mitered segments of phenolic-foam insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.08 FIELD-APPLIED JACKET APPLICATION

A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of jacket manufacturer's recommended adhesive.
3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.
2. Apply lap or joint strips with the same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Apply jackets with 1-1/2 inch laps at longitudinal seams and 3-inch wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor retarder jackets and exposed insulation with vapor-retarder mastic.

C. Apply PVC jacket where indicated, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

D. Apply metal jacket where indicated, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.09 FINISHES

A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.10 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Chrome-plated pipes and fittings, unless potential for personnel injury.
7. Sanitary, waste vent, propane, medical gas/vacuum and chemical wastes.

3.11 FIELD QUALITY CONTROL

A. Inspection: Engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

B. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect fittings and valves randomly selected by Architect.
2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

C. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

D. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.12 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.13 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Heating hot-water supply and return.

1. Operating Temperature: 100 to 200°F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:

a. Steel or Copper Pipe

1) Pipe sizes, 1-1/2 inch or smaller, 1 inch.
2) Pipe sizes, 2 inch or larger, 2 inch.

4. Field-Applied Jacket: Foil and paper.
5. Thermal Conductivity of insulation shall be 0.27 BTU per inch/(h*ft^{2}*°F).
6. Vapor Retarder Required: Yes.
7. Finish: None.

B. Service: Steam and condensate, boiler feed water and steam blow down piping not concealed in pipe trenches.

1. Operating Temperature: 201°F to 250°F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:

a. Steel Pipe:

1) Pipe size 1-1/2 inch and smaller = 1-1/2 inch insulation.
2) Pipe size 1-1/2 inch and larger = 3 inch insulation

4. Thermal conductivity of insulation shall be 0.27 BTU per inch./(h*ft^{2}*°F).
5. Field-Applied Jacket: Foil and paper.
6. Vapor Retarder Required: Yes.
7. Finish: None.

C. Service: Generator exhaust pipe.

1. Operating Temperature: 80°F to 1200°F.
2. Insulation Material: Calcium Silicate.
3. Insulation Thickness: Apply the following insulation thicknesses:

a. Steel pipe, all sizes = 4 inch insulation.

4. Thermal conductivity of insulation shall be 0.41 BTU per inch./(h*ft^{2}*°F) at 200°F and 0.65 BTU per inch./(h*ft^{2}*°F) at 700°F.

5. Field Applied Jacket: None.
6. Vapor Retarder Required: No
7. Finish: None

3.14 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building.

B. Service: Generator exhaust pipe where exposed to physical contact and muffler.

1. Operating Temperature: 80°F to 1200°F.
2. Insulation Material: Cellular glass without jacket.
3. Insulation Thickness: Apply the following insulation thicknesses:

   a. Steel pipe and muffler, all sizes = 4 inch insulation.

4. Thermal conductivity of insulation shall be 0.41 BTU per inch./(h*ft^2*°F) at 200°F and 0.65 BTU per inch./(h*ft^2*°F) at 700°F.
5. Field Applied Jacket: Aluminum.
6. Vapor Retarder Required: No
7. Finish: None

3.15 INDOOR AIR QUALITY PROTECTION

A. Mineral fiber insulation edges, ends, and joints shall be positively and permanently sealed with insulation covering to preclude the release of insulation particles to the indoor environment.

B. Insulation applied to equipment inside air ducts, plenums, air handlers, etc. shall be positively sealed and permanently protected from erosion into the airstream using approved insulation covering

END OF SECTION 15083

SECTION 15122

THERMOMETERS AND GAUGES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes gauges for mechanical systems.

1.03 SUBMITTALS

A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gauge, fitting, specialty, and accessory specified.

B. Shop Drawings: Include schedule indicating manufacturer's number, scale range, fittings, and location for each meter and gauge.

C. Product Certificates: Signed by manufacturers of thermometers and gauges certifying accuracies under specified operating conditions and compliance with specified requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Pressure Gauges:

a. Ashcroft Inc.
b. H. O. Trerice Co.
c. Weksler Glass Thermometer Corp.
d. Weiss Instruments, Inc.

2. Test Plugs:

a. Flow Design, Inc.
b. H. O. Trerice Co.
c. MG Piping Products Co.
d. Peterson Equipment Co., Inc.
e. Sisco Manufacturing Co., Inc.
f. Watts Regulator Company; Watts Water Technologies, Inc.

2.02 PRESSURE GAUGES

A. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.

B. Case: Drawn steel, brass, or aluminum with 4-1/2-inch- diameter, glass lens.

C. Connector: Brass, NPS 1/4.

D. Scale: White-coated aluminum with permanently etched markings.

E. Accuracy: Grade B, plus or minus 2 percent of middle 50 percent of scale.

F. Range: Comply with the following:

1. Vacuum: 30 inches Hg of vacuum to 15 psig of pressure.
2. Fluids under Pressure: Two times the operating pressure.

2.03 PRESSURE-GAUGE FITTINGS

A. Valves: NPS 1/4 brass or stainless-steel needle type.

B. Syphons: NPS 1/4 coil of brass tubing with threaded ends.

C. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

2.04 TEST PLUGS

A. Description: Nickel-plated, brass-body test plug in NPS 1/2 fitting.

B. Body: Length as required to extend beyond insulation.

C. Pressure Rating: 500 psig minimum.

D. Core Inserts: Two self-sealing valves, suitable for inserting 1/8-inch OD probe from dial-type thermometer or pressure gauge.

E. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.

F. Test Kit: Pressure gauge and adapter with probe, two bimetal dial thermometers, and carrying case.

1. Pressure Gauge and Thermometer Ranges: Approximately two times the system's operating conditions.

PART 3 - EXECUTION

3.01 THERMOMETERS AND GAUGE INSTALLATION, GENERAL

A. Install gauges and accessories according to manufacturer's written instructions for applications where used.

3.02 PRESSURE-GAUGE INSTALLATION

A. Install pressure gauges in piping tees with pressure-gauge valve located on pipe at most readable position.

B. Install dry-type pressure gauges in the following locations:

1. Suction and discharge of each pump.
2. Where indicated on Drawings.

C. Install liquid-filled-type pressure gauges at suction and discharge of each pump.

D. Install pressure-gauge needle valve and snubber in piping to pressure gauges.

3.03 ADJUSTING AND CLEANING

A. Adjust faces of thermometers and gauges to proper angle for best visibility.

B. Clean windows of thermometers and gauges and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 15122

SECTION 15181

HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes piping, special-duty valves and accessories for: generator cooling piping, louver plenum drain piping, and generator exhaust piping. Requirements apply to any temporary piping installed for the systems identified.

B. Related Sections include the following:

1. Division 7 Section "Through-Penetration Firestop Systems" for materials and methods for sealing pipe penetrations through fire and smoke barriers.
2. Division 15 Section "Basic Mechanical Materials and Methods" for general piping materials and installation requirements.
3. Division 15 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
4. Division 15 Section "Thermometers and Gages" for thermometers, and pressure gages.
5. Division 15 Section "Mechanical Identification" for labeling and identifying hydronic piping.
6. Division 15 Section "Mechanical Vibration and Seismic Controls".

1.03 SUBMITTALS

A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.

B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Copies of certificates for welding procedures and personnel.

D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Failed test results and corrective action taken to achieve requirements.

E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.04 QUALITY ASSURANCE

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

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.05 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Through-Penetration Firestop Systems" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.02 COPPER TUBE AND FITTINGS

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

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless) or Type F (furnace-butt welded), Grade A, Schedule 40, black steel, plain ends or threaded ends.

B. Steel Pipe, NPS 2-1/2 through NPS 14: ASTM A 53, Type E (electric-resistance welded), Grade A, Schedule 40, black or 304 stainless steel, plain ends.

C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250.

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

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

H. Wrought, Cast and Forged Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

I. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

J. Packed, Slip, Expansion Joints: 150-psig minimum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, packing ring, packing, limit rods, flanged ends, and chrome-plated finish on slip-pipe telescoping section.

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

L. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.04 VALVES

A. Butterfly valves

1. Use in sizes 4 inch and larger for hydronic shut-off valve service only.
2. Lug body style, cast iron body, ductile iron disc, carbon steel shaft, bronze bushings, and steel handle.
3. EPDM seat rated for continuous duty at 300°F.
4. Tight shutoff to 200 psi.
5. Threaded bolt holes in valve body.
6. Centerline Series LT or equal.
7. For valves 5 inches and larger, provide gear operator with crank handle or handwheel. Gear-operated valves located overhead equipped with chain operators.

B. Water drain valves (hose bibbs): 100 psi bronze valves with threaded hose-end male connections, provide with cap and chain. Watts No. B-6000-CC or equal.

C. Gauge cocks: bronze, 100 psi rated, threaded cocks, Lunkenheimer Fig. 981 or equal.

D. Ball valves

1. Use for all hydronic shut-off valves in sizes 3 inch and smaller.

2. Two-piece, full port, threaded end, 150 psi rated at 200 °F.
3. Bronze body, chrome plated brass ball, brass stem, Teflon seat, high profile, steel handle with vinyl cover.
4. Provide stem extensions on handles where insulation thickness impedes operation of handle.
5. Nibco, Watts or Apollo only.

E. Plug cocks: 150 psig rated at 200 °F, bronze, square head, screwed or flanged as required, straight-away plug cocks, Lunkenheimer or equal.

2.05 DIELECTRIC FITTINGS

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

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

C. Dielectric Flanges:

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

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150 or 300 psig minimum working pressure as required to suit system pressures.

D. Dielectric-Flange Kits:

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

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
3. Separate companion flanges and steel bolts and nuts shall have 150 or 300 psig minimum working pressure where required to suit system pressures.

E. Dielectric Couplings:

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

a. Calpico, Inc.
b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300 psig minimum working pressure at 225 °F.

F. Dielectric Nipples:

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

   a. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300 psig minimum working pressure at 225 °F.

2.06 HYDRONIC SPECIALTIES

A. Manual Air Vent: See detail on Drawings.

B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure; 240 °F operating temperature; Spirovent, no exceptions taken.

C. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150 psig minimum working pressure and 250 °F maximum operating temperature. Connectors shall have flanged- or threaded-end connections to match equipment connected and shall be capable of ¾ inch misalignment.

2.07 GENERATOR EXHAUST SPECIALTIES

A. Insulated Roof Thimble: Shall be by Silex Innovations Inc., or approved equal, sized for 10" diameter schedule 40 steel piping.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Generator Cooling Piping: Use Type L drawn-temper copper tubing with soldered joints or Schedule 40 steel pipe with threaded joints.

B. Generator Exhaust Pipe Interior and Insulated Exterior: Schedule 40 steel pipe with welded joints.

C. Generator Exhaust Pipe Exterior Exposed: Schedule 40 304 stainless steel pipe with welded joints.

D. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.02 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball, and butterfly valves.

B. Install shutoff duty valves at connection to each piece of equipment.

3.03 PIPING INSTALLATIONS

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

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

D. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

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

F. Anchor piping for proper direction of expansion and contraction.

3.04 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable steel clevis hangers or adjustable roller hangers for individual horizontal piping 20 feet or longer.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1-1/2 and smaller: Maximum span, 8 feet; minimum rod size, 3/8 inch.
2. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
3. NPS 2-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
4. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 4: Maximum span, 10 feet; minimum rod size, 1/2 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 1-1/2 and smaller: Maximum span, 8 feet; minimum rod size, 3/8 inch.
2. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

3.06 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, and elsewhere as required for system air venting.

B. Install automatic air vents in mechanical equipment rooms only at high points of system piping, and elsewhere as required for system air venting.

3.07 FIELD QUALITY CONTROL

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

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

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

3.08 ADJUSTING

A. Perform these adjustments before operating the system:

1. Open valves to fully open position.
2. Check pump for proper direction of rotation.
3. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
4. Lubricate motors and bearings.

3.09 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

B. Initial flushing:

1. Remove loose dirt, mill scale, metal chips, weld beads, rust and like substances without damage to any system component. Bypass factory cleaned equipment unless acceptable means of protection are provided. Isolate or protect clean system components, including pumps, and remove any component, which may be damaged. Open all valves, drains, vents, and strainers at all system levels.

2. Remove plugs, caps, spool pieces and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 6 feet per second. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean.

C. Cleaning:

1. Circulate Liquid Detergent cleaning agent (at agent concentration recommended by agent manufacturer) at 180°F to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide and like substances not removed by initial flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Isolate equipment, which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system to circulate at velocities not less than 6 feet per second. Circulate each section for not less than 4 hours. Blowdown all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

D. Final flushing:

1. Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up water. Flush all dead ends and isolated clean equipment. Gently operate each valve to dislodge any debris in valve body by throttling. Flush for not less than 1 hour.
2. Provide all temporary circulating pumps required to circulate water through piping systems.
3. When piping systems are complete and functional, systems shall be tested under normal operating conditions. Operating tests shall demonstrate that piping systems function as designed without objectionable noise or vibration.

3.10 LABELING AND IDENTIFICATION

A. Install labeling, identification and valve tags in accordance with Division 15 Section "Mechanical Identification".

END OF SECTION 15181

SECTION 15189

HVAC WATER TREATMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes water-treatment systems for the following:

1. Generator cooling systems (closed-loop system).

1.03 PERFORMANCE REQUIREMENTS

A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.

B. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. At completion of project and upon completion of pipe cleaning, furnish and install water treatment systems for hydronic hot water system, chilled water system, and condenser water system.

D. Include all chemicals, feed tanks and accessories as required to furnish a complete water treatment system as recommended by Owner's Chemical Treatment Company.

E. Include one year service program by Chemical Company. Service calls as often as required to keep all systems in proper operation. Service shall include supervision of installation of chemical feed equipment and start up of systems.

F. Treatment systems to be as follows:

1. Generator cooling systems

a. Scale/corrosion inhibitor.
b. Biocide.
c. Glycol.

1.04 SUBMITTALS

A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:

1. Chemicals.
2. Chemical feeders.

B. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.05 MAINTENANCE

A. Scope of Service: Provide chemicals and service program for maintaining optimum conditions in the generator cooling systems. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, including the following:

1. Initial water analysis and recommendations.
2. Startup assistance.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical assistance.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Chemicals: Furnish quantity equal to 10 percent of amount initially installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. HVAC Water-Treatment Products:

a.

2.02 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, dissolved oxygen, biocount, chloride, and total alkalinity and for calcium hardness field tests.

2.03 CHEMICALS

A. Furnish chemicals recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment.

B. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.

1. Quantity: As required.

C. Biocide: Chlorine release agents or microbiocides.

1. Quantity: As required.

D. Closed-Loop, Water Piping Chemicals: Sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.

1. Quantity: As required.

2.04 PROPYLENE GLYCOL

A. Generator cooling system piping loop to be filled with premixed solution of 40% (by weight) inhibited propylene glycol, 60% water, or as required by generator manufacturer. Before installing glycol mix, drain all portions of hot water system.

B. Inhibited propylene glycol shall be nontoxic and provide maximum solution freezing point of -14°F when mixed with water in specified proportions. Propylene glycol shall be formulated with 1.75% dipotassium phosphate inhibitor or another approved inhibitor.

C. Dowfrost Heat Transfer Fluid by Dow Chemical Company or equal.

D. At completion of work and with hot water loop full of antifreeze, leave in factory-sealed container(s) for Owner (10) gallons, for each different system, of pre-mixed glycol with inhibitor.

E. Provide test kit for Owner to check inhibitor concentration.

PART 3 - EXECUTION

3.01 WATER ANALYSIS

A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article.

3.02 INSTALLATION

A. Install treatment equipment level and plumb.

B. Add cleaning chemicals as recommended by manufacturer.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.04 CLEANING OF HYDRONIC PIPING SYSTEMS

A. For each generator cooling system HVAC water treatment supplier shall supervise the cleaning of hydronic systems in accordance with Section 15181.

B. Provide written report that hydronic systems have been cleaned in a satisfactory manner.

3.05 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to perform startup service.

1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

3.06 ADJUSTING

A. Occupancy Adjustments: Within 12 months of Substantial Completion, perform water analyses of each system to prove that chemical treatment systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

B. Review manufacturer's safety data sheets for handling of chemicals.

C. Schedule at least 1 hour of training Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 15189

SECTION 15191

FUEL-OIL PIPING AND PUMPSET

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes fuel-oil and/or diesel-fuel piping within the building. Products include the following:

1. Steel pipe and fittings.
2. Pipe specialties and valves.
3. Fuel-transfer pumps.
4. Fuel maintenance system.

B. Related Sections include the following:

1. Division 7 Section "Through-Penetration Firestop Systems".
2. Division 15 Section "Hangers and Supports".
3. Division 15 Section "Mechanical Vibration and Seismic Controls".
4. Division 15 Section "Mechanical Identification".

1.03 PERFORMANCE REQUIREMENTS

A. Minimum Working-Pressure Ratings: Unless otherwise indicated, minimum pressure requirements for fuel oil piping is 150 psig.

1.04 SUBMITTALS

A. Product Data: For the following:

1. Specialty valves.
2. Fuel-oil transfer pumps. Include rated capacities, operating characteristics, furnished specialties, accessories, pressure ratings, dimensions, and written description of controls.

B. Shop Drawings: Fuel-oil piping and equipment. Include plans, attachments to other work.

1. Wiring Diagrams: Power, signal and control wiring.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For fuel-oil transfer pumps to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

D. Comply with NFPA 30, "Flammable and Combustible Liquids Code," and NFPA 31, "Installation of Oil Burning Equipment," for fuel oil piping materials, components, installations, testing, and inspecting.

1.06 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists the following requirements apply to product selection:

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

2.02 PIPING MATERIALS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B, black. Wall thickness of wrought-steel pipe shall comply with ASME B36.10M.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
3. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11 forged steel.
4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
5. Gasket Material: Thickness, material, and type suitable for fuel oil.

B. Transitions Fittings: Type, material, and end connections to match piping being joined.

C. Pipe Connectors: UL 567, swivel or compression type for connection to equipment.

D. Y-Pattern Strainers: Minimum 125-psig working pressure; cast-iron body (ASTM A 126, Class B), threaded connections, perforated stainless-steel basket and bottom drain connection.

E. Basket Strainers: Minimum 125-psig working pressure; high tensile cast-iron body (ASTM A 126, Class B), threaded- or flanged-end connections, bolted cove, perforated stainless-steel basket and bottom drain connection.

F. Flexible Connectors: UL listed for fuel oil systems; stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250°F maximum operating temperature.

G. Pressure and vacuum gages are specified in Division 15 Section "Thermometers and Gauges".

2.03 SPECIALTY VALVES

A. Oil Shutoff Valves: UL 842; metal-body ball valve with threaded ends according to ASME B1.20.1 for pipe threads.

B. Check valves

1. 2" and smaller
2. Threaded end, threaded cap, swing check, Class 125.
3. Bronze body, bronze cap, Teflon disc.
4. Stockham Fig. B-320T or equal.

C. Gauge cocks: Bronze, 100 psi rated, threaded cocks, Lunkenheimer Fig. 981 or equal.

D. Ball valves:

1. Two-piece, full port, threaded end, 150 psig rated at 200°F.
2. Conform to requirements of UL 842.
3. Bronze body, chrome plated brass ball, brass stem, Teflon seat, steel handle with vinyl cover.
4. Apollo, no substitutions.

E. Manual air vent valves: 1/4", bronze, 125 psig rated, gauge cocks, Lunkenheimer Fig.1180 or equal.

F. Fusible link valve:

1. Lever operated quick closing mechanism with zinc plated mallable iron lever.
2. 125 lb, screwed full-ported, bronze body and disc.
3. Installation kit to include 25 feet of wire and (2) 165°F fusible links.
4. Preferred Utilities Model 110 fire safety fuel shut-off valve or equal.

G. Fusomatic valve:

1. Globe valve with integral spring and fusible element.
2. Valve to close tightly if temperature reaches 165°F.
3. Preferred Utilities Fusomatic valve or equal.

H. Antisyphon valve

1. Heavy bronze body with oil proof gasketing, spring loaded poppet, composition seat and dashpot.
2. Spring to be rated for 5 ft. hd.
3. Preffered Utilities Model A or equal.

I. Back pressure regulating valves

1. Bronze body, threaded, 250 psig rated working pressure.
2. Cast iron body, balanced cage and polished stainless steel trim spring range 30 to 150 psig.
3. Preferred Type V Back Pressure Regulators Valve or equal.

J. Pressure-Reducing Valves: UL listed for fuel oil service. Include bronze body with 250-psig minimum pressure rating. Preferred Utilities Model 0 or equal

2.04 FUEL OIL DAY TANK

A. Comply with NFPA 30.

B. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled, return pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Pump Capacity: Exceeds maximum flow of fuel supply pump at 110 percent of rated capacity.
3. Tank level sensor: Starts fuel supply pump and opens normally closed solenoid valve to maintain fuel level in day tank.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and closes normally open solenoid valve at midpoint between overflow level and 100 percent of normal fuel level.
6. Pump controller: Liquid-level device starts return pump when fuel level exceeds 100 percent of normal fuel level.
7. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, atmospheric vent line, emergency vent line, overflow line; and tank drain line with shutoff valve.
8. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

C. Manufacturer:

1. Pryco

D. Tank Capacity:

1. 75 gallon for emergency generator.

2.05 FUEL-OIL TRANSFER PUMPS

A. Duplex Fuel-Oil Transfer Pump Sets: Factory-fabricated and –wired, package unit; for fuel oil service, listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction; skid mounted with base and strainer, two fuel oil pumps, and controls.

1. Manufacturers:

a. Preferred Utilities Manufacturing Corporation.
b. Smith-Koch, Inc.
c. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Base: Steel with pumps, accessories and controls factory mounted.
3. Pumps: Comply with HI M109, two positive displacement rotary type pumps with cast iron housing and self adjusting mechanical seals. Pumps with aluminum, brass or bronze housings or rotors are not acceptable. Packing gland equipped pumps, closed-coupled pumps, carbonator shaft mounted pumps or centrifugal pumps are not acceptable. Include foot-mounted, cast-iron housing; steel gears; bronze bearings; steel shaft; mechanical seals; and built-in pressure relief bypass.
4. Drive: Direct coupled.
5. Motors: Comply with Division 15 Section "Motors".
6. Valves: Provide isolation valves, check valves and accessories as detailed on Drawings.
7. Piping: Steel with ferrous fittings and threaded or welded joints.
8. Strainer: Duplex, basket type with corrosion-resistant-metal-screen baskets and differential pressure monitoring.
9. Controls:

    a. Automatic operation using microprocessor based controls.
    b. Automatic pump alternator after 168 hours of operation or automatic changeover to the lag pump if the lead pump fails.
    c. Broken-line, oil shutoff feature.
    d. Interface with automatic control system is specified in Division 15 Section "Controls" to indicate the following:

        1) BAS interface for monitoring 8 alarm points.

            a) Pump 1 fail.
            b) Pump 2 fail.
            c) Strainer High Differential.
            d) Pumpset leak.
            e) Broken fuel line.
            f) 3 alarms to be determined.

    e. Remote start/stop of pumpset through Building Automation System.

10. Capacities and Characteristics:

    a. See Schedule on Drawings.

2.06 FUEL MAINTENANCE SYSTEM

A. Manufacturers:

1. Fuel Technologies, International, LLC.
2. Preferred Utilities Manufacturing Corporation.

B. Fuel Oil Filter System: Factory fabricated and wired; for fuel oil filtration fuel with enclosure, filter, fuel-oil pump, and controls; FMG approved, listed, and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction.

1. Enclosure: NEMA 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.
2. Pump: Comply with HI M109, steel-gear-with-crescent, positive-displacement, direct-coupled, rotary-type, cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
3. Motor: Comply with Division 15 Section "Motors."
4. Piping: Steel with ferrous fittings and threaded or welded joints.

5. Five-Stage System:

   a. Fuel staining: Large contaminates are removed.
   b. Primary Filtration: Initial fuel filtration.
   c. Centrifuge: Separates solids and water through centrifugal action.
   d. Coalescing: Smaller water droplets and solids coalesce on the conical baffle and fall to the collection bowl.
   e. Secondary Filtration: 2-micron fuel filtration.

6. Programmable Logic Controller:

   a. Alarm on excess water in filter, filter saturated, high water level in filter and system basin leak detected.
   b. Factory mounted and wired control cabinet.
   c. Microprocessor based with keyboard; and backlit, LCD display.

7. Interface with automatic control system is specified in Division 15 Section "Controls" to control and indicate the following:

   a. Start/stop system when required by schedule.
   b. Operating status.
   c. Alarm off-normal status.

8. Capacities and Characteristics:

   a. See Schedule on Drawings.

PART 3 - EXECUTION

3.01 FUEL PIPING APPLICATIONS

A. Fuel Oil Piping in Building, NPS 2 and Smaller: Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges.

B. Day tank "Vent" Piping, NPS 1-1/2" and Larger: Schedule 40 steel pipe, with welded joints using Schedule 40 wrought-steel welding fittings and Class 150 wrought-steel flanges. All piping outside building to be painted by Mechanical Contractor with rust resistant paint.

C. NPS 2 and Larger

3.02 EXAMINATION

A. Examine roughing-in for fuel-oil piping system to verify actual locations of piping connections before equipment installation.

   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 CONCRETE BASES

A. Install fuel oil transfer pumps and day tank on concrete bases. Concrete bases are specified in Division 15 Section "Basic Mechanical Materials and Methods."

3.04 PIPING INSTALLATION

A. General piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Identify fuel oil piping and equipment as specified in Division 15 Section "Mechanical Identification"

C. Use eccentric reducer fittings to make reductions in pipe size. Install fittings with level side down.

D. Install strainer on inlet side of control valves, pressure-reducing valves, fuel-oil pumps and oil burner connections.

E. Install sediment traps at points where sediment or condensate may collect. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate would be subject to freezing.

1. Construct sediment traps using tee fitting and bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

F. Install pressure gage(s) at the following locations:

1. At suction and discharge piping of each fuel oil pump.
2. Inlet and outlet side of strainers.

3.05 JOINT CONSTRUCTION

A. Pipe joint construction is specified in Division 15 Section "Basic Mechanical Materials and Methods."

3.06 VALVE INSTALLATION

A. General valves installation is specified in Division 15 Section "Valves."

B. Install valves in accessible locations, protected from damage.

C. Install ball valves at branch connections to supply mains and at equipment.

D. Install drain valves at piping low points.

E. Identify valves as specified in Division 15 Section "Mechanical Identification."

3.07 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Division 15 Section "Hangers and Supports."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 and Smaller: Maximum span, 60 inches; minimum rod size, 3/8 inch.
2. NPS 3/4 to 1-1/4: Maximum span, 84 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2 to 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

C. Support vertical steel pipe at each floor and at spacing not greater than 15 feet.

3.08 CONNECTIONS

A. Install piping adjacent to equipment to allow service and maintenance.

B. Connect piping to equipment with ball valve and union. Install union between valve and equipment.

C. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.

D. Ground equipment according to Division 16 Section "Grounding and Bonding".

E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.09 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.
2. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fuel-oil pumps. Refer to Division 1 "Closeout Procedures."

3.11 LABELING AND IDENTIFICATION

A. Install labeling, identification and valve tags in accordance with Division 15 Section "Mechanical Identification".

END OF SECTION 15191

SECTION 15815

METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air distribution systems in pressure classes from minus 2 to plus 6 inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round spiral-seam ducts and formed fittings.
3. Sheet metal materials.
4. Hangers and supports.

B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.03 DEFINITIONS

A. NUSIG: National Uniform Seismic Installation Guidelines.

1.04 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air moving, air distribution equipment, and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

B. Surfaces in contact with the airstream shall comply with requirements of ASHRAE 62.1-2007.

1.05 SUBMITTALS

A. Shop Drawings: CAD generated to 1/4 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling and wall mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

C. Welding certificates.

D. Field quality-control test reports.

1.06 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 7, "Exhaust Duct Systems," for range hood ducts, unless otherwise indicated.

PART 2 - PRODUCTS

2.01 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed ducts.

E. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 SEALANT MATERIALS

A. Duct sealing

1. Seal all *transverse* and *longitudinal* joints on all ductwork joints.
2. Continuously seal all other ductwork joints and seams on all ductwork including branch take-offs, access doors, fire dampers, screw penetrations at hangers, flexible duct connections to rigid ductwork, flexible duct connections to diffuser transition, diffuser transition connections to diffuser.
3. Continuously seal all joints between duct and diffuser assemblies and between duct and grille assemblies.
4. Continuously seal all joints between duct drops and duct mains.
5. Duct sealant: adhesive-backed tape with 10" w.g. pressure rating.
6. Where space and joint configuration do not allow use of adhesive-backed tape, as determined by Engineer, use water-based duct mastic. Do not use duct mastic for any given duct sealing application without prior written approval from Engineer.
7. Prior to installation of ductwork, submit proposed materials and methods of duct sealing. Ductwork shall not be installed prior to approval of duct sealing methods.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Complying with NFPA requirements for Class 1 ducts.
11. UL 723 listed.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.03 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Steel Cables for Galvanized Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized Steel Ducts: Galvanized steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel support materials.
3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.04 SEISMIC-RESTRAINT DEVICES

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

1. Cooper B-Line, Inc.; Division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop or field fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 492, stainless steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted support system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.05 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, as detailed on Drawings, and when approved in writing by Engineer, other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Nexus Inc.
c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Lockformer.

2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.06 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.

I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

J. Duct dimensions on Drawings are inside clear dimensions. When duct liner is used, increase size of metal ducts to accommodate duct liner.

2.07 ROUND DUCT AND FITTING FABRICATION

A. Round, Spiral Lock-Seam Ducts: Fabricate ducts of materials according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers

a. McGill AirFlow Corporation
b. SEMCO Incorporated

2. Longitudinal lock-seam round ductwork shall not be used on project.

B. Duct Joints:

1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.

C. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

E. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 3 to 10 inch wg:

a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.

3. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.

4. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
5. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
6. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
7. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
8. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
9. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
10. Pleated Elbows for Sizes through 14 Inches in diameter and pressures through 10-Inch wg: 0.022 inch.

PART 3 - EXECUTION

3.01 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Outside Air Ducts (Constant Volume Systems): 2 inch wg.
2. Exhaust Ducts (Negative Pressure): 2 inch wg.

3.02 DUCT MATERIAL SCHEDULE

A. Outside air duct systems:

1. Galvanized steel sheets.

B. General Exhaust Systems

1. Galvanized steel sheets.

3.03 DUCT SEALING SCHEDULE

A. Water based duct sealants

1. Outside air duct systems in building
2. Exhaust duct systems in building

3.04 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire and smoke control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. All ductwork shall be supported from structural steel unless alternate support scenario is approved in writing by Structural Engineer. Do not support ductwork from roof decks or floor decks unless approved in writing by Structural Engineer. All auxiliary structural steel required for the support of ductwork shall be provided and installed by Mechanical Contractor.

O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."

P. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

Q. Protect duct interiors from the elements and foreign materials until building is occupied by Owner. Follow SMACNA's "Duct Cleanliness for New Construction." For general hospital spaces duct cleanliness shall meet or exceed the requirements for "Intermediate Level". Failure to follow these requirements will result in the requirement of complete cleaning of duct systems by Mechanical Contractor, at no additional expense to Owner.

R. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 painting Sections.

S. Where ceiling space is limited, slip and drive connections shall be used instead of flanged duct connections to minimize the space required for duct and duct insulation installation.

3.05 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

F. Ductwork that is not insulated shall be cleaned by installer and surfaces shall be prepared to accept prime painting by others.

3.06 SEISMIC RESTRAINT DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

1.02 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to this Specification and SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated and as required in this section.

1. All duct joints for all pressure classes shall be adequately sealed to pass duct testing requirements.

B. Seal ducts before external insulation is applied.

3.08 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.09 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.10 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" on all new ductwork and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Components not to be included in duct tests:

    a. Exhaust fans.

3. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
4. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

    a. Allowable Leakage, Medium Pressure Supply Duct Systems: 1 percent of design airflow for entire system from AHU to VAV Terminals.
    b. Allowable Leakage, Low Pressure Supply Duct Systems: 1 percent of design airflow for entire system from AHU to Reheat Coils.
    c. Allowable Leakage, Return Duct Systems: 2 percent of design airflow.
    d. Allowable Leakage, Exhaust Supply Duct Systems: 2 percent of design airflow.
    e. Allowable Leakage, Supply Duct Systems, Terminals to Air Outlets: 2 percent of design airflow.

5. Where ductwork is tested in multiple sections, the total leakage measured shall be added to determine total leakage for entire system. Leakage for entire system shall not exceed "Allowable Leakage".
6. Remake leaking joints and retest until leakage is equal to or less than maximum

allowable.

3.11 CLEANING NEW SYSTEMS

A. Cleaning of new duct systems will be required only if Mechanical Contractor does not exercise prescribed methodology identified in Paragraph 3.02.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

C. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Create other openings to comply with duct standards.
2. Remove and reinstall ceiling sections to gain access during the cleaning process.

D. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

E. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Exhaust fans including fan housings, plenums scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Exhaust-air ducts, dampers, and actuators.
4. Outside-air ducts, dampers, actuators, and turning vanes.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

G. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and re-inspect ducts.

3.12 LABELING AND IDENTIFICATION

A. Install labeling, identification and valve tags in accordance with Division 15 Section "Mechanical Identification".

END OF SECTION 15815

SECTION 15820

DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:

1. Volume dampers.
2. Motorized control dampers.
3. Fire dampers.
4. Turning vanes.
5. Duct mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.
9. Louvers

B. Related Sections include the following:

1. Division 15 Section "HVAC Controls" for electric and pneumatic damper actuators.

1.03 SUBMITTALS

A. Product Data: For the following:

1. Volume dampers.
2. Motorized control dampers.
3. Fire dampers.
4. Turning vanes.
5. Duct mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Louvers

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
2. Manual volume damper installations.
3. Motorized control damper installations.
4. Fire damper installations, including sleeves and duct-mounting access doors.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.04 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.05 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.02 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 VOLUME DAMPERS

A. Manufacturers:

1. Penn Ventilation Company, Inc.
2. Ruskin Company.
3. Vent Products Company, Inc.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

C. Standard Volume Dampers: Multiple or single blade, parallel or opposed blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2. Roll-Formed Steel Blades: 0.064 inch thick, galvanized sheet steel.
3. Aluminum Frames: Hat-shaped, 0.10 inch thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
4. Roll-Formed Aluminum Blades: 0.10 inch thick aluminum sheet.
5. Extruded-Aluminum Blades: 0.050 inch thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings: Molded synthetic.
8. Tie Bars and Brackets: Aluminum.
9. Tie Bars and Brackets: Galvanized steel.

D. Jackshaft: 1 inch diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple damper assembly.

E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32 inch thick zinc-plated steel, and a ¾ inch hexagon locking nut. Include center hole to suit damper operating rod size. Include elevated platform for insulated duct mounting.

F. Manual balance dampers: Factory manufactured, 16-gauge (minimum thickness) galvanized steel, Ruskin Model MD25 or MDRS25 or equal, complete with position locks and position indicators.

G. Shop fabricated dampers will not be accepted.

H. Volume dampers above concealed, inaccessible ceilings: Young Regulator/Bowden Cable Control System consisting of a Young Regulator 5020-CC, round butterfly damper designed for external control including all necessary hardware for connection to Bowden cable control kit. Bowden 270-301 Cable Control Kit to be installed flush with ceiling and include cover plate with tamper resistant screws, controller and appropriate length of casing/control wire for connection to damper operator.

I. Volume damper handle to be identified with minimum 36 inch length of 2 inch wide surveyors tape.

2.04 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Greenheck.
2. Penn Ventilation Company, Inc.
3. Ruskin Company.
4. Arrow United Industries

B. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- thick, galvanized-steel damper blades with maximum blade width of 8 inches.

1. Secure blades to ½ inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade linkage hardware of zinc-plated steel and brass, ends sealed against spring stainless steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Provide parallel or opposed blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inch wg when damper is being held by torque of 50 in-lbf; when tested according to AMCA 500D.

C. Control dampers for roof mounted exhaust fans: 4-6 inches wide, opposed, air-foil style blades with flexible sealing strips. Arrow Foil Aluminum Minimum Leakage Damper OBDAF-207 by Arrow United Industries or equal.

D. Damper actuators to be Belimo, no substitutions permitted.

2.05 DYNAMIC FIRE DAMPERS

A. Manufacturers:

1. Greenheck.
2. Penn Ventilation Company, Inc.
3. Ruskin Company.
4. Pottoroff

B. Fire dampers shall be labeled according to UL 555 Dynamic Rating.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034 inch thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory or field installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034 inch thick, galvanized sheet steel. In place of interlocking blades, use full length, 0.034 inch thick, galvanized steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless steel closure spring.

I. Fusible Links: Replaceable, 165 deg F rated.

2.06 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2 inch wide, double vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:

a. Ductmate Industries, Inc.
b. Duro Dyne Corp.
c. METALAIRE, Inc.
d. Ward Industries, Inc.

2.07 DUCT-MOUNTING ACCESS DOORS

A. Manufacturers:

1. Ductmate Industries, Inc.
2. Greenheck.

B. General Description: Fabricate doors airtight and suitable for duct pressure class.

C. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

D. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Coordinate first subparagraph and list below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semi-proprietary specifications.

F. Provide number of hinges and locks as follows:

1. Less Than 12 Inches Square: Secure with two sash locks.
2. Up to 18 Inches Square: Two hinges and two sash locks.
3. Up to 24 by 48 Inches: Three hinges and two compression latches.
4. Sizes 24 by 48 Inches and Larger: One additional hinge.

G. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

H. Insulation: 1 inch thick, fibrous-glass or polystyrene-foam board.

2.08 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Duro Dyne Corp.
2. Ventfabrics, Inc.
3. Ward Industries, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4 inch wide, 0.028 inch thick, galvanized sheet steel or 0.032 inch thick aluminum sheets. Select metal compatible with ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.09 FLEXIBLE DUCTS

A. Manufacturers:

1. Atco Series/UPC #036.

B. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.

1. Pressure Rating: 6 inch wg positive and 0.75 inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

C. Flexible Duct Clamps: Stainless steel clamp, in sizes 3 through 18 inches to suit duct size.

D. Minimum R-value: 6.0

E. Flame spread-less than 25, smoke developed - less than 50, in conformance with NFPA 90A and 90B.

F. Install in lengths of 48 inches or less.

G. Stainless steel clamp in sizes 3 through 16 inches to suit duct size. Duct clamps to be screwdriver or nut-driver driven stainless steel band.

H. Fasten each flexible duct end to rigid duct or square to round transition using both hose style clamp and duct joint tape.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.11 LOUVERS

A. By Mechanical Contractor.

B. See Section 10200.

PART 3 - EXECUTION

3.01 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Provide duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

D. Provide balancing dampers at points on supply and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

E. Provide test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.

G. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. Downstream from volume dampers and equipment.
2. Adjacent to fire dampers, providing access to reset or reinstall fusible links.
3. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
4. On sides of ducts where adequate clearance is available.

H. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body Plus Ladder Access: 25 by 17 inches.

I. Install the following sizes for duct mounted, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter.
2. Two-Hand Access: 10 inches in diameter.
3. Head and Hand Access: 12 inches in diameter.
4. Head and Shoulders Access: 18 inches in diameter.
5. Body Access: 24 inches in diameter.

J. Install the following sizes for duct mounted, pressure relief access doors:

1. One-Hand or Inspection Access: 5 inches in diameter.
2. Two-Hand Access: 10 inches in diameter.
3. Head and Hand Access: 13 inches in diameter.
4. Head and Shoulders Access: 19 inches in diameter.

K. Label access doors according to Division 15 Section "Mechanical Identification."

L. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

M. For fans developing static pressures of 5 inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts directly, do not use flexible ducts.

O. Connect flexible ducts to metal ducts with stainless steel hose-style clamp.

P. Install duct test holes where indicated and required for testing and balancing purposes.

Q. Fasten each flexible duct end to rigid round duct using ***both*** hose-style clamp and duct joint tape. Hose-style clamp to be screwdriver or nut-driver driven stainless steel band, or equal. Duct joint tape to be adhesive backed, minimum 3 inches wide, 5 inch w.g. rated, Hardcast or equal.

3.02 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire dampers for proper action.

C. Final positioning of manual volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION 15820

SECTION 15837

FANS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes:

1. Tubeaxial Fans
2. Propeller Fans

1.03 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on sea-level conditions.

B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

C. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.07 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.08 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Barry Blower Div./Penn Ventilation Companies, Inc.
2. Exhausto (for combustion air fan and controls, and MDVS system)
3. Greenheck Fan Corp.
4. Hartzell Fan, Inc.
5. Loren Cook Company
6. Trane Co. (The).
7. Twin City Fan & Blower Company

2.02 TUBEAXIAL FANS

A. Description: Fan wheel and housing, factory mounted motor with belt drive, inlet cone section, and accessories.

B. Housing: Steel with flanged inlet and outlet connections.

C. Wheel Assemblies: Cast or extruded aluminum with airfoil shaped blades mounted on cast iron wheel plate keyed to shaft with solid steel key.

D. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
2. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
3. Motor Pulleys: Adjustable pitch. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
6. Motor Mount: Adjustable base.
7. Shaft Bearings: Radial, self-aligning ball or roller bearings.

    a. Ball Bearing Rating Life: ABMA 9, L50 of 400,000 hours.
    b. Roller Bearing Rating Life: ABMA 11, L50 of 400,000 hours.
    c. Extend lubrication lines to outside of casing and terminate with grease fittings.

E. Accessories:

1. Support: Pair of supports bolted to fan housing of same material as housing.
2. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300°F.
3. Motor Cover: Cover with side vents to dissipate motor heat of same material as housing.

F. Motors: Comply with requirements in Division 15 Section "Motors."

G. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked enamel finish coat after assembly.
3. Coatings: Electrostatically applied baked polyester powder coating.

2.03 PROPELLER FANS

A. Description: Wall mounted fan, belt driven, steel propeller exhaust fan.

B. Housing: Steel.

C. Propeller: Fabricated steel design with blades securely fastened to a minimum 7 gauge hub. The hub shall be keyed and locked to the fan shaft utilizing two setscrews. Propeller shall be balanced in accordance with AMCA Standard 204-96 Balance Quality and Vibration Levels for Fans.

D. Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Drive: Precision machined cast iron type, keyed and securely attached to the wheel and motor shafts.
2. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
3. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
4. Motor Mount: Adjustable base.
5. Shaft Bearings: Radial, self-aligning regreasable ball bearings.

    a. Ball Bearing Rating Life: ABMA 9, L50 of 200,000 hours.
    b. Extend lubrication lines to outside of casing and terminate with grease fittings.

E. Motors: Comply with requirements in Division 15 Section "Motors."

F. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked enamel finish coat after assembly.
3. Coatings: Electrostatically applied baked polyester powder coating.

2.04 MOTORS

A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.

B. Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency.

2.05 SOURCE QUALITY CONTROL

A. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Support suspended units from structure using threaded steel rods and spring hangers. Vibration-control devices are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

1. In seismic zones, restrain support units.

C. Install units with clearances for service and maintenance.

D. Label fans according to requirements specified in Division 15 Section "Mechanical Identification."

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 FIELD QUALITY CONTROL

A. Prepare the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and connections to ducts and electrical components are complete.
3. Verify that proper thermal overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.
2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Replace fan and motor pulleys as required to achieve design airflow.

H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

3.05 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 1 Section "Contract Procedures."
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.07 COMMISSIONING

A. Commissioning of fans shall be performed by air and water balancing contractor.

B. Commissioning process shall include:

1. Confirmation that power supply to unit is complete and is left in on position.
2. Automatic temperature controls are complete.
3. Fan operation is quiet.
4. Fan airflows meet requirements of contract documents.
5. All devices are accessible for servicing.
6. Sequence automatic temperature controls to cycle motor operated dampers and confirm that controls operate correctly.

C. Air and water balancing contractor shall submit commissioning report for final review and approval by Mechanical Engineer.

3.08 LABELING AND IDENTIFICATION

A. Install labeling, identification and valve tags in accordance with Division 15 Section "Mechanical Identification".

END OF SECTION 15837

SECTION 15855

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 15 Section "Duct Accessories" for fire dampers and volume-control dampers not integral to diffusers, registers, and grilles.
2. Division 15 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.03 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.04 SUBMITTALS

A. Product Data: For each model indicated, include the following:

1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.
2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.

B. Coordination Drawings: Reflected ceiling plans and wall elevations drawn to scale to show locations and coordination of diffusers, registers, and grilles with other items installed in ceilings and walls.

1.05 QUALITY ASSURANCE

A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

A. Sidewall Supply Diffusers (WSG)

1. Aluminum construction with baked, off-white enamel finish.
2. Double deflection grille with vertical deflection blades located at diffuser face.
3. Extruded aluminum opposed blade dampers.
4. Inside of duct connection to grille to be painted black.
5. Metalaire Model V4002M or equal by Krueger, Tuttle & Bailey, Titus, Price, or Nailor.

B. Return and exhaust grilles (EG, WEG, RG)

1. Aluminum construction with baked, off-white enamel finish.
2. Surface mounted on drywall ceilings, drywall walls and suspended ceilings.
3. 45° fixed deflecting vanes for vision protection.
4. Capacity control dampers: in drywall ceiling only.
5. Factory finished, square to round transition, minimum 4" deep, inside painted black.
6. Metalaire Model RH or equal by Krueger, Tuttle & Bailey, Titus, Price, or Nailor.

C. Insides of ductwork and duct transitions connected to grilles and diffusers to be painted flat black so that no bare sheet metal is visible through grilles and diffusers from occupied spaces.

2.02 SOURCE QUALITY CONTROL

A. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.04 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 15855

SECTION 15950

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow within distribution systems, including sub-mains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting HVAC systems to provide indicated quantities.
3. Measuring electrical performance of HVAC equipment.
4. Setting quantitative performance of HVAC equipment.
5. Verifying that automatic control devices are functioning properly.
6. Reporting results of the activities and procedures specified in this Section.
7. Participation in final commissioning of equipment, review all Division 15 Sections requirements.
8. Verification of duct pressure tests performed by Mechanical Contractor.
9. Vibration measuring.

B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.03 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including sub-mains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

L. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

M. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

N. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

O. TAB: Testing, adjusting, and balancing.

P. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

Q. Test: A procedure to determine quantitative performance of systems or equipment.

R. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.04 SUBMITTALS

A. Qualification Data: Within **15** days from Contractor's Notice to Proceed, submit **6** copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 15 days from Contractor's Notice to Proceed, submit 6 copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit **6** copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.05 QUALITY ASSURANCE

A. TAB Firm Qualifications: Mechanical Contractor will engage a TAB firm certified by either AABC or NEBB. Mechanical Contractor is responsible for participating in the TAB process, as outlined in this Section, and shall carry all costs associated with this participation.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. The Contract Documents examination report.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.06 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide five days' advance notice for each test. Include scheduled test dates and times.

C. Perform verification tests of duct pressure tests completed by Mechanical Contractor.

D. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.08 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
3. Make recommendations for additional balancing devices that may be required to assist in the TAB process. Make recommendations in Contract Documents Examination Report.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine equipment for installation and for properly operating safety interlocks and controls.

L. Examine automatic temperature system components to verify the following:

1. Dampers and other controlled devices are operated by the intended controller.
2. Dampers are in the position indicated by the controller.
3. Integrity of dampers for free and full operation and for tightness of fully closed and fully open positions.
4. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
5. Sensors are located to sense only the intended conditions.
6. Sequence of operation for control modes is according to the Contract Documents.
7. Controller set points are set at indicated values.
8. Interlocked systems are operating.
9. Changeover from heating to cooling mode occurs according to indicated values.

M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 VERIFICATION OF DUCTWORK LEAKAGE TESTS

A. Mechanical Contractor shall be responsible for performing ductwork leakage tests in accordance with Section 15815, 3.6.

B. TAB shall be responsible for verification of Mechanical Contractor's test results.

1. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
2. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

   a. Allowable Leakage, Supply Duct Systems: 2 percent of design airflow.
   b. Allowable Leakage, Exhaust Duct Systems: 2 percent of design airflow.

3. When testing ductwork in sections, total leakage through the cumulative total of all sections shall not exceed allowable leakage.

C. Certify if test results obtained by Mechanical Contractor are acceptable.

3.04 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound units.

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

D. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

K. Check for proper sealing of air duct system.

3.06 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.07 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.

6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.08 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:

1. Solid-state circuitry with a piezoelectric accelerometer.
2. Velocity range of 0.1 to 10 inches per second.
3. Displacement range of 1 to 100 mils.
4. Frequency range of at least 0 to 1000 Hz.
5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.

1. Use a calibrator provided with the vibration meter.
2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

1. Turn off equipment in the building that might interfere with testing.
2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp.

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

1. Fans:

a. Fan Bearing: Drive end and opposite end.
b. Motor Bearing: Drive end and opposite end.
c. Equipment Casing: Top and side.
d. Equipment Base: Top and side.
e. Building: Floor.
f. Ductwork: To and from equipment after flexible connections.
g. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.

1. Verify that vibration isolation is installed in the required locations.
2. Verify that installation is level and plumb.
3. Verify that isolators are properly anchored.
4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.09 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check bearings and other lubricated parts for proper lubrication.
4. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.

1. Fans are clean.
2. Bearings and other parts are properly lubricated.
3. Deficiencies noted in the preconstruction report are corrected.

3.10 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.11 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply outlets: 0 to plus 5 percent. (If 100 CFM is specified air flow, acceptable air flow readings will be between 100 CFM and 105 CFM.)
2. "General" return or exhaust inlets: 0 to less 5 percent. (If 100 CFM is specified exhaust/return air flow, acceptable air flow readings will be between 100 CFM and 95 CFM.)
3. Exhaust Fans: Plus 0 to plus 5 percent.

3.12 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.13 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outside- and exhaust-air dampers.
    b. Fan drive settings including settings and percentage of maximum pitch diameter.
    c. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Balancing stations.
4. Position of balancing devices.

F. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and size.
    e. Manufacturer's serial number.
    f. Arrangement and class.
    g. Sheave make, size in inches, and bore.
    h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Motor Data:

    a. Make and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
    g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

H. Vibration Measurement Reports:

1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

I. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.14 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Verify that balancing devices are marked with final balance position.
c. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner, Architect, and Construction Manager

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner, Architect, and Construction Manager.
3. Owner and/or Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.15 PREFERRED BALANCING CONTRACTORS

A. Thomas – Young and Associates

B. Tekon Associates

C. Milharmer Associates

3.16 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 15950

SECTION 15975

CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, and applicable sections of Division 15 and Division 16, apply to this Section.

B. See Section 15820 for damper requirements.

C. Review Section 15050 for additional requirements.

D. Review all Division Sections for additional Commissioning requirements.

1.02 SECTION INCLUDES

A. Direct Digital Controls

1. A fully integrated building automation system (BAS) incorporating direct digital control (DDC) technology for energy management, equipment monitoring and control. All new DDC technology shall integrate with the existing BAS.
2. All hardware including microprocessors, monitoring terminals, control cabinet enclosures, electronic sensors, electronic controllers, electronic actuators, electric actuators, interface devices, valves, dampers and safety devices.
3. All communication and control wiring associated with the BAS and necessary for its operation, temperature control components, equipment starting circuits and building alarm systems.
4. Software upgrades as required to make a complete and working system as described herein and in the "Sequence of Operations" and "Points List" shown on the drawings.

B. Local Electric Controls

1. Complete installation of local electric controls, including factory supplied integrated controls, for those mechanical items and mechanical systems where control will not be accomplished through the BAS.
2. Equipment and systems to be provided with local electric controls include, but are not limited to:

1.03 REFERENCES

A. The latest issue of applicable standards and recommended practices of the following agencies shall form a part of the specification.

1. ASHRAE *Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration* (ISBN 0-910110-77-8).
2. ASHRAE Guideline 13 – Specifying Direct Digital Control Systems.
3. ANSI/ASHRAE Standard 135 – BACnet.
4. National Electrical Code (NEC).
5. National Electrical Manufacturer's Association (NEMA).
6. International Building Code (IBC).
7. International Mechanical Code (IMC).
8. Institute of Electrical and Electronics Engineers IEEE).
9. National Institute of Standards and Technology (NIST).

10. Federal Communications Commission (FCC).
11. American National Standards Institute (ANSI).
12. Electronic Industries Association (EIA).
13. National Fire Protection Association (NFPA).
14. Underwriters Laboratories (UL).

1.04 APPROVED BAS SUBCONTRATORS

A. Trident Controls, Inc. – Contact Terry Bowen at (207) 829-4001

B. Alternates: Alternate BAS subcontractors will not be considered.

1.05 QUALITY ASSURANCE

A. Codes and Standards:

1. All equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. Refurbished or reconditioned components are not acceptable.
2. All components shall comply with NEMA standards.
3. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
4. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference.
5. Applicable BAS components shall comply with UL 916 PAZX and 864 UDTZ.
6. All BAS systems components shall be the product of the same manufacturer.

B. The system shall be designed, installed, commissioned and serviced by an authorized agent of the BAS manufacturer. This agent shall be factory trained, FCC licensed and shall have a minimum five (5) years of documented experience installing entire facility wide building automation systems of the type described in this specification.

C. BAS system is intended to be a vendor designed system, with the system incorporating general control strategies provided by the Engineer of Record. Control strategies detailed on the Drawings are to be included in the control algorithms provided by the BAS subcontractor. BAS subcontractor shall include all necessary hardware, software and system descriptions to create a complete, operating system of controls.

1.06 BAS SYSTEM DESCRIPTION

A. The BAS shall consist of a network of stand-alone DDC controllers, providing distributed processing capability and serving up web pages to interface via menu penetrations with the existing Operator Workstations. The BAS installation for this project shall allow for future expansion of both input/output points and processing/control functions.

B. BAS installation shall include:

1. Software, interconnecting wire and conduit.
2. Application specific DDC controllers.
3. Electric and electronic damper motors.
4. Sensing elements.

1.07 SUBMITTALS

A. Submit under provisions of Division 1.

B. Shop Drawings: Submit ten complete sets of documentation:

1. System configuration with trunk cable schematic showing programmable control unit locations, trunk data conductors, peripheral devices, batteries, power supplies, ladder diagrams, modems and interface wiring diagrams.
2. Damper schedules.
3. Equipment data cut sheets.
4. Sequence of operations.
5. Panel layouts.
6. Representations of all system graphics.
7. Auto-CAD compatible as-built drawings.

C. Product data: Provide data for each system component and software module.

D. Manufacturer's installation instructions: Include for all manufactured components.

1.08 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 1.

B. Accurately record actual locations of all control components, including panels, thermostats, and sensors, etc.

C. Revise shop drawings to reflect actual installations and operating sequences.

D. Include data specified in "Submittals" in final "Record Documents" form.

1.09 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 1.

B. Upon completion of installation, submit operation and maintenance manuals consisting of the following:

1. Index page listing contents in alphabetical order.
2. Manufacturer's equipment parts list of all functional components of the system.
3. Auto-CAD disk of system schematics, including wiring diagrams.
4. Sequence of Operations and Points List.
5. As-built interconnection wiring diagrams.
6. Operator's Manual.
7. Trunk cable schematic showing remote panel locations, and all trunk data.
8. List of connected data points, including panels to which they are connected and input device (ionization detector, thermostat, etc.)
9. Conduit routing diagrams.

1.10 PRE-INSTALLATION CONFERENCE

A. Under provisions of Division 1, BAS subcontractor shall convene a conference one week prior to commencing work of this Section.

B. Require attendance of parties directly affecting the work of this Section.

C. Review locations of field installed equipment, work schedule, and coordination with other trades.

1.11 COORDINATION

A. Coordinate work under provisions of Division 1, and applicable sections of Division 15 and Division 16.

B. Ensure that installation of components is complementary to installation of similar components in other systems.

C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

D. Ensure that systems are completed and commissioned.

1.12 WARRANTY

A. Provide all services, materials, and equipment necessary for the successful operation of the entire BAS system and all local controls for a period of one year after beneficial use.

B. The adjustment, required testing, and repair of systems includes all computer equipment, transmission equipment and all sensors and control devices.

C. The on-line support services shall allow the local BAS subcontractor to monitor and control the facility's BAS via internet connection supplied by the owner.

PART 2 - BAS PRODUCTS

2.01 NETWORKING COMMUNICATIONS

A. The design of the BAS shall network existing operator workstations and stand-alone DDC Controllers, both new and existing. The network architecture shall consist of two levels, a high performance peer-to-peer BACnet network, and application specific LON networks with access being totally transparent to the user when accessing data or developing control programs.

B. The design of the BAS shall allow the seamless co-existence of new DDC controllers with existing DDC controllers in the same network without the use of gateways or protocol converters.

2.02 DDC CONTROLLER/MAIN PANEL PROCESSOR

A. DDC Controllers shall be stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list. Each controller shall support a minimum of three (3) LAN Device Networks.

1. Network communication capability shall include a minimum network of 200 main panels, each supporting their own network of distributed control modules.

B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes.
2. Energy management applications.
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified.
5. Maintenance support applications.
6. Custom processes.

7. Operator I/O.
8. Dial-up communications.
9. Manual override monitoring.

C. Each DDC Controller shall support any combination of industry standard inputs and outputs.

D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

E. DDC Controllers shall provide a minimum of two ethernet communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or terminals.

F. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local touch screen displays.

1. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

G. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

H. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards.

J. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 168 hours.

1. In the event of loss of normal power, the DDC Controllers shall re-start equipment provided with emergency power in a pre-programmed sequence designed to manage the load on the emergency power system as equipment comes back on line. The BAS Contractor shall submit a proposed re-start sequence to the architect for review and approval.
2. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention, and shall re-start equipment in a pre-programmed sequence designed to manage the load on the normal power system as equipment comes back on line. The BAS Contractor shall submit a proposed re-start sequence to the Architect for review and approval.
3. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local COM port, via telephone line dial-in, or from a network workstation PC.

2.03 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

A. General;

1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
2. The software shall be capable of supporting a minimum of 30,000 application specific DDC input and output points.

B. Control Software Description:

1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:

a. Two-position control.
b. Proportional control.
c. Proportional plus integral control.
d. Proportional, integral, plus derivative control.
e. Automatic tuning of control loops.

C. DDC Controllers shall have the ability to perform any or all the following energy management routines:

1. Time of Day/Calendar Based Scheduling:

a. Equipment scheduling shall be used to decrease energy consumption by turning off equipment or automatically adjusting control/ setpoint limits and overrides during unoccupied periods.
b. Equipment schedules shall be permitted based on one or a combination of the following: time of day schedule, an input state, an output state or another points schedule. Time of day/day of week shall have a minimum of four on/off times per day programmable in one-minute increments (seven days per week).
c. A minimum of 48 discrete schedules shall be programmable per DDC panel. Groups of loads (consisting of 128 loads each) shall be programmable for concurrent scheduling.

2. Holiday Scheduling:

a. Equipment schedules shall be adjustable for holidays.

3. Temporary Scheduling:

a. Time of day/day of week schedules shall allow temporary adjustment to schedules for Today and Tomorrow that will automatically revert to defined weekly schedule without additional operator modification.

4. Setpoint/Setback Control:

a. Setpoint/Setback Control shall decrease energy consumption by modifying space temperature setpoints during scheduled unoccupied hours, thereby reducing use of mechanical heating or cooling.

5. Optimized Start/Stop:

a. Optimized Start/Stop program shall decrease energy consumption by learning the building thermal characteristics and capacity of the HVAC systems to respond to variable conditions and automatically turn on HVAC as late as possible prior to occupancy and off as early as possible prior to unoccupied periods.

6. Duty Cycle Control:

   a. Duty Cycle Control shall decrease energy consumption by cycling applicable equipment (air handling units, supply fans, return air fans, exhaust fans, and the like) by shedding and restoring those loads on a cyclic basis to reduce total run time. Cycle interval and on time shall be programmable. Maximum off and minimum on times shall be programmable to prevent damage to equipment.

7. Demand Limit Control:

   a. Demand Limit Control shall monitor and control demand KW for the facility. Demand Limit Control shall be able to monitor up to 4 electric meters, or pulse-type watt transducers with different KWH/pulse multipliers and integrate information from any or all of these inputs to calculate the electrical energy usage over either a 15 or 30 minute sliding demand window.
   b. Demand peak shall be limited by turning loads on and off, or by adjusting setpoints, to keep peak below a programmed setpoint. Control shall be based on 30-second integration of demand, the rate of increase or decrease, and the historic effects of load shedding and restoring. Minimum on times, maximum off times and other limits and overrides shall be programmable.

8. Economizer/Enthalpy Control (Free Cooling):

   a. Economizer Control shall reduce energy consumption by utilizing outside air, when available, during cooling cycles of HVAC systems.
   b. Economizer programming shall allow for definition of sequence (software interlocks), limits, lockouts and schedules.
   c. The Enthalpy Control Program shall be used to reduce energy consumption of mechanical cooling equipment by measuring air temperature and humidity in two air streams and calculating and comparing the total heat content (enthalpy) of the air from each source.

9. Lead/Lag Control Program:

   a. The Lead/Lag Program shall automatically determine sequence of operation for up to four primary equipment loads per module. The sequence shall be based on accumulated run hours during any operator specified interval.
   b. The lead/lab switching interval must be owner programmable by hours, days, or month.

10. Meter/Counter Points:

    a. DDC Controllers shall have the ability to read pulsed inputs for metering and counting applications. The program will multiply the pulses by a value, and totalize the values over user defined time intervals. This can be used for applications such as metering Cubic Feet per Minute (CFM), Gallons per Minute (GPM), etc.

D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.
2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation (new or existing) local I/O device or communications with other panels (new or existing) on the network.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.
4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm message to more fully describe the alarm condition or direct operator response.
5. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.

F. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for points as specified in the I/O summary.

1. Any point, physical or calculated, may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controller's point group. Two methods of collection shall be allowed: either by a pre-defined item interval or upon a pre-defined change of value. Sample intervals of one minute to seven days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 20,000 data samples. All trend data shall be available for use in third party personal computer applications.
2. DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.

    a. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation or remotely using dial-in modems. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.

G. DDC Controllers shall automatically accumulate and store run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O summary.

2.04 APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs).

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tracking, real-time digital control processor. Provide the following types of ASCs as a minimum:

1. Terminal Equipment Controllers.

C. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.

D. Terminal Equipment Controllers:

1. Provide for control of each piece of equipment, including, but not limited to, the following:

a. Exhaust fans.

2. Controllers shall include all input and output points necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal controllers utilizing proprietary control signals and actuators shall not be acceptable.

2.05 PERSONAL COMPUTER OPERATOR WORKSTATION HARDWARE

A. Use owners existing PC-based operator workstation to seamlessly interface with and manage all new BAS components.

2.06 WORKSTATION OPERATOR INTERFACE

A. Operator interface shall remain as it is with existing BAS and existing operator workstation. Use of passwords, alarm management, trend logging, operator activity tracking, report generation, equipment scheduling, collection and analysis of historical data, etc. shall remain as is functionally but with the expanded system and with the expanded connections of controlled and monitored equipment.

B. Dynamic Color Graphic Displays:

1. Create multi-color graphic floor plan displays for each new floor area showing graphic report of each sensed temperature. Interface and integrate these dynamic floor plan displays with existing floor plans to provide a seamless display of floor plans where new and old display components are indistinguishable.
2. Create color graphic system schematic for each piece of mechanical equipment, including:

a. Fans
b. Fuel pumping and storage systems
c. Interface of equipment controlled by other vendors.

3. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands. Graphics software shall permit the importing of AutoCAD or Bitmap drawings for use in the system.
4. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

C. System Configuration & Definition:

1. Provide automatic backup and restoration of all new DDC Controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Changes made at the DDC Controllers shall be automatically uploaded to the workstation, enduring system continuity.

D. Workstation Communications:

1. The Owners existing Head-End computer shall be able to communicate with the new DDC Controllers.

a. Communication protocol shall be TCP/IP or equal non-proprietary LAN/WAN sharing protocol.
b. Use of Ethernet shall not require the use of an independent file server.

2.07 SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Thermistor temperature sensors as follows:

a. Accuracy: Plus or minus 0.5°F at calibration point.
b. Wire: Twisted, shielded-pair cable.
c. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
d. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. length as required.
e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
f. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
g. Room Sensors: To be selected by ATC and approved by Owner.

2. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed
b. Set-Point Indication: Exposed.
c. Thermometer: Concealed
d. Orientation: Vertical or Horizontal.

3. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
4. Outside-Air Sensor: 20 to 95 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40°F to plus 170°F.
5. Duct and Room Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
6. Humidity sensors for spaces and for high-limit control in ducts: To be selected by ATC and approved by Owner.

2.08 THERMOSTATS

A. Low-Voltage, On-Off Thermostats: Bimetal-actuated, 24 V, switch action SPST or equivalent solid-state type, with either adjustable or fixed anticipation heater, 2°F maximum differential, and vented cover.

2.09 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
3. Nonspring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Spring-Return Motors for Dampers Smaller than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
b. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
e. Dampers with 2 to 3 Inches wg of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
f. Dampers with 3 to 4 Inches wg of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.

2. Coupling: V-bolt and V-shaped, toothed cradle.
3. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
4. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
5. Power Requirements (Two-Position Spring Return): 24-V ac.
6. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
8. Temperature Rating: Minus 22°F to plus 122°F.
9. Temperature Rating (Smoke Dampers): Minus 22°F to plus 250°F.
10. Run Time: 12 seconds open, 5 seconds closed.

2.10 DAMPERS

A. Dampers: AMCA-rated, opposed-blade design; 0.1084-inch minimum, galvanized-steel frames with holes for duct mounting; damper blades shall not be less than 0.0635-inch galvanized steel with maximum blade width of 8 inches.

1. Blades shall be secured to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40°F to plus 200°F.
3. For standard applications, include optional closed-cell neoprene edging.
4. For low-leakage applications, use design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inches wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.

B. All motor operated dampers and damper actuators for exhaust fans and louvered openings to be furnished by ATC.

C. All damper actuators shall be Belimo.

2.11 CONTROL CABLE

A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 16 Section "Control/Signal Transmission Media.

2.12 BAS POINTS

A. BAS points to be input or output, binary or analog, as required. See Drawings for general information. BAS subcontractor shall supplement points list on Drawings as required to create a complete, operating, system of controls.

PART 3 - EXECUTION

3.01 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:

1. Construct and maintain project schedule.
2. On-site coordination with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions from Owner/Architect.
4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.
6. Coordination/Single point of contact.

3.02 POINTS LIST AND SEQUENCE OF OPERATIONS

A. See drawings.

B. The contractor shall collaborate with the Owner directly to determine the Owner's preference for naming conventions, etc. before entering the data into the system.

C. Control of mechanical equipment not otherwise mentioned in specifications or sequence of operations shall be as proposed by BAS Contractor with review and approval by Architect. Submit proposed sequence of operations during submittal period.

3.03 START-UP AND COMMISSIONING

A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power.

B. Provide recommendations for system modifications in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior approval of Owner.

C. BAS project manager shall work in conjunction with Balancing Subcontractor during the testing and balancing phase of the project.

D. BAS project manager shall work in conjunction with Architect and Owner to perform system verification at completion of project.

E. 60 hours of commissioning

1. Hour slips to be signed/verified by Construction Manager.

3.04 TRAINING

A. The BAS Contractor shall provide factory-trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The Contractor shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 AM to 4:30 PM weekdays.

B. Provide 40 hours of training for Owner's designated operating personnel. Training shall include:

1. Explanation of drawings, operations and maintenance manuals.
2. Walk-through of the job to locate control components.
3. Operator workstation and peripherals.
4. DDC Controller and ASC operation/function.
5. Operator control functions including graphic generation and field panel programming.
6. Operation of portable operator's terminal.
7. Explanation of adjustment, calibration and replacement procedures.
8. Student binder with training modules.

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If such training is required by the Owner, it will be contracted at a later date.

D. After completion of start-up and commissioning, provide 40 hours of reprogramming time at Owner's site for system modifications requested by Owner.

3.05 CONTROL WIRING

A. The BAS Contractor shall install all 120 volt and low voltage control wiring from power supplies terminated by Division 16 to meet system requirements.

1. All low voltage wiring installed in concealed/accessible areas such as above suspended ceilings, in stud walls, control cabinets, etc. will be cabling, not in conduit. Plenum rated cabling will be used where required by code. All cabling will be sized per National Electric Code.
2. All low voltage communications and sensor wiring in the exposed space area will be wall mounted in WIREMOLD V700 - Ivory finish at intersection of wall and ceiling.
3. All wiring installed in exposed areas such as mechanical rooms, tunnels, trenches, and mechanical shafts will be installed in conduit.
4. The conduit installation will be sized, installed and supported in accordance with the National Electrical Code.

3.06 SEQUENCE OF OPERATION

A. Refer to drawings for general information. BAS subcontractor shall be responsible for developing control algorithms incorporating information provided on drawings as well as additional requirements to create a complete operating system of controls. BAS subcontractor shall incorporate control algorithms included on other, similar, equipment at this facility.

3.07 TESTING AND COMMISSIONING

A. BAS Contractor shall attend and assist in on-site commissioning process for all controls, BAS and local, at the conclusion of this project. BAS Contractor shall coordinate these efforts with Mechanical Contractor and provide support services as required by Mechanical Contractor during the commissioning process.

B. BAS Contractor shall work in conjunction with Mechanical Contractor and Air and Water Balancing Contractor in the commissioning of fans, fan coil units, baseboard radiation, and other equipment noted in Division 15.

C. BAS Contractor shall work in conjunction with Mechanical Contractor and Mechanical Engineer in the final commissioning of Air Handling Units, Rooftop Energy Recovery Units, Chillers, and Cooling Towers.

END OF SECTION 15975