SECTION 22 00 01- MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general provisions of the Contract apply to the work specified in DIVISION 22 and 23 including Scope of Work Section.

B. Separation of Divisions into Sections is for convenience only and is not intended to establish limits of work.

1.2 SCOPE

A. Provide labor, materials and equipment for complete and operating systems.

1.3 DRAWINGS

A. The drawings are diagrammatic and are intended to show the general arrangement and approximate physical sizes of equipment, piping and ductwork. Every nut, bolt, brace, hanger, etc., is not indicated or specified; all items required, necessary or incidental, for the proper and dependable operation of each system shall be provided under this Division whether specifically referred to or not. Refer to architectural drawings for all necessary dimensions.

1.4 CODES AND PUBLICATIONS

A. Work shall be executed in accordance with best engineering practices, guidelines, and the latest edition of all applicable Codes and Publications which shall include but shall not be limited to the following:

1. UFC
2. International Mechanical Code
3. International Plumbing Code
4. ASPE Data Book
5. ASHRAE Publications
6. Mississippi State Fire Marshal Act
7. SMACNA, Sheet Metal and Air Conditioning Contractors National Association
8. NFPA - 101, Life Safety Code and Publications
9. NFPA - 90A, Standard for the Installation of Air Conditioning & Ventilating Systems
10. NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems
10. NFPA - 70, National Electrical Code

B. Where the above are at variance with the drawings or specifications, the more stringent requirements shall be applicable.

1.5 REVIEW, PERMITS AND INSPECTIONS

A. Apply for and pay for governmental reviews and permits. Arrange for and pay inspection and service connection fees incidental to the mechanical work including the cost of utility main connections and extensions if required.

B. No work shall be concealed until approved by the local inspector and the Architect. Local regulations shall be adhered to.

C. Upon completion, a Certificate of Approval from the appropriate regulatory agency shall be

provided to the Architect.

1.6 VISITING SITE

A. The Bidder shall visit the site of proposed work so that he may understand the facilities, difficulties, and restrictions attending the execution of the Contract. He will be allowed no additional compensation for failure to be so informed.

1.7 WORK IN OTHER DIVISIONS

A. Prior to bidding, coordinate all items of work referred to as "work of other Divisions" to insure items are not omitted or duplicated.

B. Power wiring and raceways for mechanical equipment except power disconnect switches, will be provided under DIVISION 26 - ELECTRICAL. Mechanical equipment shall be provided with factory installed integral disconnects unless indicated otherwise on electrical drawings. If factory installed disconnects are not available and not indicated on electrical drawings, mechanical contractor shall coordinate requirements with electrical contractor, obtain written verification of contractor to provide and install disconnect(s) per NEC and manufacturer=s requirements at no additional cost.

C. Supports for equipment, except supports specifically indicated to be provided under other Divisions, shall be provided under this Division. Supports shall be checked and coordinated under this Division to insure that they suit the equipment to be installed.

D. Damaged surfaces of factory finished items shall be repaired to the satisfaction of the Architect as the work of this Division. Nameplates shall be protected until painting has been accomplished. Protection shall be removed and nameplates cleaned prior to acceptance of equipment.

E. Access Doors will be provided under this division for installation under other divisions.

1.8 MANUFACTURER'S RECOMMENDATIONS

A. Equipment and materials provided under this Division of the specifications shall be installed according to manufacturer's recommendations. Review all manufacturers' application and installation instructions prior to ordering equipment or commencing with the work. If the drawings or specifications show or describe any deviations from the manufacturer's recommendations, request clarification from the Architect and provide as directed at no additional cost to the Owner.

1.9 GUARANTEE AND SERVICE

A. Guarantee equipment, materials and workmanship for one year after beneficial use of a particular system, beneficial occupancy of the building or final acceptance of entire project. Where specifically indicated extended warranties shall be provided. Beginning date of guarantee will be established only after written request is received by the Architect, and agreed upon by the Architect, stating the date the systems were turned over to the Owner for beneficial use or occupancy.

B. During the one year period of guarantee, any defects in equipment, materials, or workmanship shall be promptly corrected without cost to the Owner. Mechanical and associated electrical equipment shall be serviced and adjusted without cost during the guarantee period. Servicing and adjusting shall include all labor, material, parts, etc., required during the first year.

1.11 INTERRUPTION OF SERVICES

A. Services in existing buildings are to be kept in operation at all times, except when specific permission is given to do otherwise. Before any services are interrupted, arrangements shall be made with the occupants to do this work at a time most convenient to the occupants. This procedure may involve working at night, on Saturday or Sunday, or at a special time of the year, with the length of time of the interruption agreed upon in advance. Once any service is interrupted, work to restore the service in the shortest possible time. Work to restore the service shall be on a continuous basis unless temporary service is provided or approval is obtained from the occupants to do otherwise. Temporary services indicated or required shall be provided as work of this Division. Allowance shall be made in the bid for the cost of all overtime in this connection.

1.12 DEMOLITION

A. Demolition work shall conform to the applicable requirements of DIVISION 1 - GENERAL REQUIREMENTS.

1.13 SPECIAL CONDITIONS

B. No piping, ducts or other mechanical equipment foreign to electrical equipment shall pass through or above spaces dedicated to panelboards., distribution panels, switchboards, and stairwells, elevator shafts, elevator equipment rooms and battery charging panels. Work shall conform with NFPA 70, Articles 384.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

A. Names of manufacturers and catalog numbers indicated in the Contract Documents are to establish a standard as to design and quality. Other products similar in design and of equivalent quality may be used if submitted to the Architect and found acceptable by him. Refer to General Conditions for additional information.

B. When the mechanical installer elects to use an acceptable alternate manufacturers' equipment, the mechanical installer shall be responsible to coordinate the change with all trades affected. The mechanical installer shall also pay for any additional work required under this Division as well as any other Division if the alternate equipment is used.

C. If required by Architect because of substitutions, submit for review 1/4" scale working drawings of equipment areas with plan and section views.

2.2 SUBMITTALS

A. Within 30 days after award of the Contract, and before executing any work, the Contractor shall submit for review six copies of descriptive equipment literature or shop drawings **in one complete indexed and bound submittal** for the following items:

Ductless Split A/C Systems	Condensing Units
Flexible Duct & Fittings	Insulation
Air Distribution Devices	
Fans and Accessories	Unit Ventilator
Drains	Unit Heaters
Plumbing Fixtures and Trim	Plumbing Valves and Cocks
Domestic Water Pipe	Sanitary Sewer Pipe
Refrigerant Piping	Insulation
Natural Gas Piping	

B. Where applicable submissions shall include installation drawings and brochures showing locations, methods of anchoring, connections to work of others, wall conditions at each particular installation and special floor mounting conditions.

C. Submittals shall be identified with project name, equipment name and number as indicated on the drawings, and specification paragraph reference. Submittals shall be properly marked to show proposed model number and accessories being provided and shall have the a stamp certifying the submittal has been reviewed and found to be in accordance with the specifications and drawings.

D. Submittals which do not comply with the above will be returned without review, for resubmittal.

2.3 ENCLOSURES

A. Control equipment enclosures such as, but not limited to, starters, data gathering panels, temperature control panels, etc., provided by the controls installer or provided as part of a packaged piece of equipment shall meet the following minimum standards unless specifically indicated otherwise.

B. Control equipment enclosures provided within a building or an accessible attic shall be equivalent to or greater than NEMA 1 type construction.

C. Control equipment enclosures provided outside of a building, a non-enclosed area or in an accessible crawl space under a building shall be equivalent to or greater than NEMA 3R type construction with drain and breather.

D. Control equipment enclosures provided within hazardous areas, controlling explosion-proof equipment shall be NEMA 7 or 9 type construction.

E. Where indicated on the drawings flush mounted enclosures shall be provided.

PART 3 - EXECUTION

3.1 RECORD DRAWINGS

A. Maintain during the course of the project and submit upon completion of the work, unless noted otherwise in the general conditions, two sets of project contract documents with colored pencils in a neat and understandable manner to show significant changes made during construction. Underground piping, valves and cleanouts outside of the building shall be dimensioned on the record drawings. Dimensions shall indicate the location of exterior mains with reference to the exterior building walls and/or corners.

3.2 OPERATING INSTRUCTIONS

A. Prior to the time scheduled for occupancy, provide the services of a competent mechanic to instruct the Owner in the care and operation of all equipment.

B. Before final acceptance, prepare and deliver to the Architect two bound copies of operating instructions, which shall include:
   1. Description of major components of systems, including the function of major items.
   2. Detailed operating instructions and instructions for making routine minor adjustments.
   3. Routine maintenance operations.
   4. Manufacturer's catalog data, service instructions wiring diagrams, fabrication

drawings and parts list for each piece of operating equipment.

5. Copies of equipment submittals and shop drawings, including review sheet, reviewed by and acceptable to the Architect.
6. Guarantee and Warranty Information.
7. Names and telephone numbers of all subcontractors and suppliers.

C. Literature shall be contained in hard back binders and divided into a suitable number of volumes so as to permit convenient heavy usage.

3.3 ELECTRICAL WORK

A. Refer to schedules and electrical drawings for motor voltages.

B. Motors for mechanical equipment shall be provided under this Division. The work of this Division shall include setting and aligning integral drive motors in operating position.

C. Unless noted otherwise, motor starters for mechanical equipment shall be provided under this Division and installed and electrically connected under DIVISION 26 - ELECTRICAL.

D. Any other electrical work in connection with DIVISION 23 - MECHANICAL shall be done under this Division. Control disconnects, control wiring and raceways, and all electric interlock and signalling wiring and raceways shall be provided under this Division.

E. Firestats and line voltage speed and thermostatic control devices for single phase supply and/or exhaust fans shall be provided and set under this Division and electrically connected in the branch circuit wiring under DIVISION 26 - ELECTRICAL.

F. Any other safety, signalling, and control devices such as thermostats, firestats, damper motors, valve operators, push buttons, pilot lights, control and/or monitoring panels, crank- case heaters, etc., shall be provided and wired under this Division in strict accordance with an approved wiring diagram.

G. Wiring and raceways installed under this Division shall comply in all respects with the requirements of DIVISION 26 - ELECTRICAL.

3.4 EQUIPMENT SUPPORTS

A. Unless otherwise specified, supports necessary for properly supporting the work and the equipment of this Division shall be provided under this Division. Additionally, provide isolation materials to prevent transmission of vibration to the building structure. Isolation of equipment as shown on drawings or specified is the minimum required, and any additional isolation required to prevent transmission of vibrations shall be provided under this Division, in accordance with the equipment manufacturer's recommendations.

3.5 SAFETY PANS

A. Pipe safety pan outlet to floor drain.

3.6 OPENINGS, GROUNDS AND CHASES

A. Openings, grounds, lintels and chases will be provided under other Divisions, as directed by this Division, to accommodate the piping, ductwork and equipment. Sleeves and prepared openings shall be accurately located in slabs or walls before pouring of concrete.

B. It shall be the responsibility of this Division to ascertain that chases, openings and holes are properly located.

C. Where piping passes through smoke and/or fire separations, pack annular space between sleeve and piping with safing or fire barrier material. Pipe insulation shall be terminated and sealed on each side of sleeve.

3.7 UNIONS OR FLANGES

A. Unions or flanges shall be provided at items of equipment to facilitate their easy maintenance, including tube bundle or coil removal, and/or cleaning. It shall not be necessary to remove any valve, strainer, or device to do the required maintenance. Piping connections at equipment shall be in accordance with the best engineering and installation practices. The requirements of this paragraph will be strictly enforced and if in the opinion of the Architect it is not adhered to the Contractor will be required to re-pipe the equipment as directed.

3.8 WORK RELATED TO EQUIPMENT NOT FURNISHED AS WORK OF THIS DIVISION

A. Unless specifically indicated otherwise, any required mechanical services for and required mechanical connections to items indicated on the drawings or in the specifications or items provided by the Owner shall be mechanically connected as work of this Division. The Contractor shall provide piping, valves, traps, etc., as required for complete operation of each piece of equipment.

3.9 DISSIMILAR METALS

A. Dielectric couplings shall be provided between copper, bronze or brass piping material and steel piping material or steel tanks. Dielectric unions shall be provided at equipment where hereinbefore specified for equipment maintenance.

B. Dissimilar metals shall be isolated from surface contact with each other by the use of a non-conductive material, tape, etc.

3.10 PROTECTION OF WORK

A. Protect equipment, fixtures, and work from damage. Damaged work will be rejected and replaced at no additional cost to the owner. Where possible, rooms containing new plumbing fixtures shall be kept locked until the building is turned over to the Owner. Immediately after installation of each plumbing fixture, it shall be covered with a fixture protector.

B. Mechanical equipment shall be protected from damage and from the weather. Provide adequate and proper storage facilities for items during the progress of the work. Special care shall be taken to provide protection for bearings, open connections, pipe coils, pumps, compressors and similar equipment.

3.11 CLEANING OF EQUIPMENT AND MATERIAL

A. Prior to acceptance, clean equipment and remove grease, dirt and foreign matter. Pressure regulating assemblies, traps, flush valves and similar items shall be thoroughly cleaned. Remove and thoroughly clean and reinstall liquid strainer screens after the system has been in operation 10 days.

B. Air, oil and natural gas piping shall be blown out with clean compressed air.

C. When connections are made to existing systems, do cleaning and purging of the existing systems as required to restore them to the condition existing prior to the start of work.

3.12 FRICTION LOSSES, ELECTRICAL RATINGS AND SPACE REQUIREMENTS

A. The values of air and water friction losses, electrical current ratings and space requirements for various pieces of equipment, as contained in these specifications or as scheduled, are estimated values and sizes and have been used in obtaining specifications for equipment and for sizing ducts, pipe, electric wiring and motor controls. Any necessary changes in any of these items resulting from values other than the estimated ones shown shall be the responsibility of the Mechanical Installer and shall be subject to the approval of the Architect. Pay any costs for additional labor and material required including costs of any other trade involved.

B. Should substitute equipment require different requirements from that shown on the drawings, the responsibility for the cost of the changes shall rest with this Division. Any such changes must be approved by the Architect.

3.13 MARKING OF EQUIPMENT

A. Each magnetic starter shall be suitably identified by means of 1/4" high letters cut in white laminated phenolic strip to show black letters. Additionally, each piece of mechanical equipment, where more than one of each is provided, such as but not limited to, boilers, air handling units, exhaust fans, etc., shall also be labeled. Strip shall be secured by means of two brass bolts and nuts or screws.

3.14 IDENTIFICATION OF PIPING

A. Piping, whether insulated or not shall be identified. Identification may be omitted from piping in inaccessible chases and furring and where use is obvious, due to its connection to fixtures or equipment and where the appearance would be objectionable, as in finished rooms.

B. Identification shall be placed as follows:

1. Near each valve and branch connection.
2. Above accessible ceilings wherever piping emerges or disappears from view when viewed from the floor of the room in which it is installed.
3. Labels shall not be more than 10' apart.

C. Identification of piping shall be by use of colored, waterproof, all temperature self-adhering vinyl pipe markers and directional arrows.

3.15 CHANGES TO PIPING OR DUCTS

A. Should the desire to make changes in the routing or arrangement of piping or ducts, whether for his own convenience, to avoid conflict with the work of other trades, or to conform to local codes, such changes shall not be made without the prior approval of the Architect.

3.16 STARTING AND TESTING

A. A competent and experienced service and installation mechanic shall be employed to start and adjust the equipment. The Architect reserves the right to require the test of any item of equipment or machinery. Such tests shall be conducted in the presence of the Architect.

3.17 PROJECT CLOSEOUT DOCUMENTS

A. Prior to the final acceptance of the project, deliver to the Architect, for review, the following:
1. Certificates of approval from local regulatory agencies.
2. Extended equipment warranties.

3. Signed receipts showing that keys to access doors, locked equipment, underground valve wrenches and vandal-proof screwdrivers have been delivered to the Owner.
4. Record drawings.
5. Operating instruction manuals which shall include copies of reviewed submittals and shop drawings including review sheet.
6. Results of potable water sterilization tests.
7. HVAC test and balance reports.

B. Final payment will be withheld until all applicable items have been provided to and are found satisfactory by the Architect.

END OF SECTION 22 00 01

SECTION 22 00 05 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including Scope of Work Section apply to this Section.

1.2 SUMMARY

A. This Section includes the following basic mechanical materials and methods to complement other Division 23 Sections.

1. Piping materials and installation instructions common to most piping systems.
2. Equipment nameplate data requirements.
3. Nonshrink grout for equipment installations.
4. Field-fabricated metal and wood equipment supports.
5. Installation requirements common to equipment specification Sections.
6. Mechanical demolition.
7. Cutting and patching.
8. Touch up painting and finishing.
9. Access doors.
10. Excavation and backfill

B. Pipe and pipe fitting materials are specified in piping system Sections.

1.3 DEFINITIONS

A. Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.

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

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

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

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

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

1.4 QUALITY ASSURANCE

A. Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code--Steel."

B. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

C. Comply with provisions of ASME B31 Series "Code for Pressure Piping." Certify that each

welder has passed AWS qualification tests for the welding processes involved and that certification is current.

D. ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

E. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. No additional costs will be approved for these increases, if larger equipment is approved. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements.

1.5 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 prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

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

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

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Coordinate connection of electrical services.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP

A. Equipment and materials shall be new and shall be listed by Underwriter's Laboratories, Inc. in categories for which standards have been set by that agency. Methods of installation shall be in full accord with the latest and best engineering practices. Pressure vessels, as called for by respective codes, shall be stamped ASME and National Board Commission.

2.2 PIPE AND PIPE FITTINGS

A. Refer to individual piping system specification Sections for pipe and fitting materials and joining methods.

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

2.3 JOINING MATERIALS

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

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

C. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3-mm) maximum thickness, except where 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.

D. ASME B16.20 for grooved, ring-joint, steel flanges.

E. AWWA C110, rubber, flat face, 1/8 inch (3 mm) thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.

F. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.

G. Plastic Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, except where other type or material is indicated.

H. Solder Filler Metal: ASTM B 32.

1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95 percent) and silver (approximately 5 percent), having 0.10 percent lead content.
2. Alloy Sn50: Tin (50 percent) and lead (50 percent).
3. Alloy E: Tin (approximately 95 percent) and copper (approximately 5 percent), having 0.10 percent maximum lead content.
4. Alloy HA: Tin-antimony-silver-copper-zinc, having 0.10 percent maximum lead content.
5. Alloy HB: Tin-antimony-silver-copper-nickel, having 0.10 percent maximum lead content.
6. Alloy Sb5: Tin (95 percent) and antimony (5 percent), having 0.20 percent maximum lead content.

I. Brazing Filler Metals: AWS A5.8.

J. BCuP Series: Copper-phosphorus alloys.

1. BAg1: Silver alloy.

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

L Solvent Cements: Manufacturer's standard solvents complying with the following:

M. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.

1. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
2. Poly(Vinyl Chloride) (PVC): ASTM D 2564.

N. PVC to ABS Transition: Made to requirements of ASTM D 3138, color other than orange.

O. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

P. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.

Q. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.

1. Sleeve: ASTM A 126, Class B, gray iron.
2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
3. Gaskets: Rubber.
4. Bolts and Nuts: AWWA C111.
5. Finish: Enamel paint.

2.4 PIPING SPECIALTIES

A. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type where required to conceal protruding fittings and sleeves.

B. Inside Diameter: Closely fit around pipe, tube, and insulation.
1. Outside Diameter: Completely cover opening.
2. Cast Brass: Split casting, with concealed hinge and set-screw.
3. Finish: Rough brass.
a) Finish: Polished chrome plate.

C. Stamped Steel: Split plate, with concealed hinge, set-screw, and chrome-plated finish.

D. Cast-Iron Floor Plate: One-piece casting.

E. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

F. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.

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

H. Dielectric Unions: Factory-fabricated, union assembly for 250-psig minimum working pressure at a 180 deg F temperature.

I. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150- or 300-psig minimum pressure to suit system pressures.

J. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Provide separate companion flanges and steel bolts and nuts for 150- or 300-psig minimum working pressure to suit system pressures.

K. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300-psig minimum working pressure at 225 deg F temperature.

L. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic

lining, with combination of plain, threaded, or grooved end types and 300-psig working pressure at 225 deg F temperature.

M. Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

N. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:

1. Steel Sheet-Metal: 24-gage or heavier galvanized sheet metal, round tube closed with welded longitudinal joint.
2 Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized, plain ends.
3. Cast-Iron: Cast or fabricated wall pipe equivalent to ductile-iron pressure pipe, having plain ends and integral water stop, except where other features are specified.
4. Wall Penetration Systems: Wall sleeve assembly, consisting of housing, gaskets, and pipe sleeve, with 1 mechanical-joint end conforming to AWWA C110 and 1 plain pipe-sleeve end.
5. Penetrating Pipe Deflection: 5 percent without leakage.
6. Housing: Ductile-iron casting having waterstop and anchor ring, with ductile-iron gland, steel studs and nuts, and rubber gasket conforming to AWWA C111, of housing and gasket size as required to fit penetrating pipe.
7. Pipe Sleeve: AWWA C151, ductile-iron pipe.
8. Housing-to-Sleeve Gasket: Rubber or neoprene push-on type of manufacturer's design.

O. Cast-Iron Sleeve Fittings: Commercially made sleeve having an integral clamping flange, with clamping ring, bolts, and nuts for membrane flashing.

1 Underdeck Clamp: Clamping ring with set-screws.

P. PVC Plastic: Manufactured, permanent, with nailing flange for attaching to wooden forms.

Q. PVC Plastic Pipe: ASTM D 1785, Schedule 40.

R. PE Plastic: Manufactured, reusable, tapered, cup-shaped, smooth outer surface, with nailing flange for attaching to wooden forms.

2.5 GROUT

A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.

B. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.50-MPa), 28-day compressive strength.

1. Packaging: Premixed and factory-packaged.

2.6 ACCESS DOORS

A. Doors in gypsum board or masonry construction shall be Karp type DSC-214M or Milcor style M-Standard, 16-gauge steel frame and 14-gauge steel door construction, continuous piano hinge and zinc chromate prime coat.

B. Doors in glazed or ceramic tile construction shall be same type as above except all stainless steel construction.

C. Doors in inaccessible acoustical tile ceilings, or walls with wall covering shall be Karp type KSC-210, or Milcor style AT 16-gauge steel frame and 18-gauge steel panel construction, recessed door for acoustical tile or gypsum board covered with matching wall covering, concealed hinge with a zinc chromate prime coat, and exposed edges painted white when installed in acoustical tile ceiling.

D. Doors in fire rated partitions or ceilings (up to 1 2 hour rating) shall carry UL AB @ Label; KARP style KRP-150 FR or Milcor Style.

E. Door required in types of construction not herein before specified shall suit the type and style of material in which installed.

F. Unless otherwise indicated doors shall have screw driver operated locks.

2.7 MAGNETIC STARTERS

A. Provide magnetic starters for all three phase motors. Also provide magnetic starters for single phase motors which start and stop as part of an automatic control sequence. Unless noted otherwise magnetic starters shall be across-the-line type rated per NEMA standards. Starters shall have undervoltage protection when used with momentary-contact push button stations and shall have undervoltage release when used with maintained contact push button stations. Enclosures for starters shall be as herein before specified. Starters in motor control centers shall be fully compatible with the motor control center. Provide two-speed starters for two-speed motors.

B. Starters shall be complete with integrally fused 120 volt control transformer, start-stop push button and pilot light or hand-off-auto switch and pilot light, where indicated, or as required for control. Starters for motors interlocked to run with other motors or which have automatic startstop controls (exclusive of safety controls such as firestats, freezestats, etc.) shall have hand-off-auto switch. Starter shall be wired so as not to by-pass safety controls when in the "hand" position.

C. Starter contacts shall be of silver alloy, and shall be of the double break type. The movable magnet and contact assembly, an arc hood in which the fixed contacts are mounted, solenoid cell, and thermal overload relays (one in each phase) shall be assembled and mounted on a heavy steel back plate. The only moving part shall be the magnet and contact assembly which shall move up and down. Each pole shall be enclosed in an individual arc chamber.

D. Starters for 5 horsepower and larger 3-phase motors shall include under voltage/phase-reversal/phase-loss protection relay wired into the control circuit.

E. Overload protective devices shall be selected in accordance with the motor nameplate, and shall be of the thermal inverse time limit type and shall include a manual reset type push button on the outside of the cover. Overloads shall operate on the melting alloy principle.

F. Starters shall have normally open and/or closed external electrical interlocks as required to suit equipment controlled.

2.8 MOTORS

A. Unless otherwise indicated, motors shall be constant speed, normal starting torque for pumps, high starting torque for fans (with low starting current) as required for the application. Electrical characteristics shall conform with the electrical supply as indicated

on the electrical drawings.

B. Three-phase motors shall be squirrel cage induction type.

C. Single-phase motors shall be split phase or capacitor start type with built-in thermal overload unless indicated otherwise.

D. Motors shall be guaranteed to operate continuously at full load with 10% voltage variation above or below the specified voltage. Motors shall be rated for an ambient temperature of 40 degrees C and a temperature rise not to exceed 40 degrees C.

E. Motors shall be copper wound high efficiency type and have either sleeve or prelubricated ball bearings as required for the particular application. Open drip-proof motors shall have Class B insulation. TEFC motors shall have Class F insulation.

F. Unless noted otherwise on the drawings or in the specifications, housings for motors in indoor locations shall be open drip proof (ODP) or explosion proof type. Motors in outdoor locations or subject to excessive moisture shall be totally enclosed or totally enclosed fan cooled (TEFC) type. Belt drive motors shall have bases with provisions for adjustment in field.

G. Motors provided on equipment not as an integral part of the equipment but propelling the equipment by the use of belts, sheaves, couplings, etc., shall be as manufactured by U.S. Electric, Marathon, Emerson, General Electric or approved equal. Manufacturers requesting approval shall submit evidence of a factory authorized service facility within a reasonable distance of the project to service or replace motors under warranty. Motors manufactured by or specifically for equipment manufacturers and provided as an integral part of the equipment package need not comply with the requirements of this paragraph.

2.9 PREPARED OPENINGS

A. Piping installed through masonry walls or concrete floors above grade shall pass through pipe sleeves.

B. Ducts installed through masonry walls or concrete floors above grade shall pass through 20-gauge galvanized sheet metal sleeves. Duct sleeve shall have a 1/2" maximum annular clearance around duct. Allowance shall be made for external duct wrap.

C. Exposed piping passing through masonry walls shall be fitted with chromium plated escutcheons on each side of the wall. Exposed ductwork passing the masonry walls shall be fitted with a 2" wide sheet metal flange around all four sides of duct on each side of the wall.

2.10 FIRE BARRIER MATERIAL

A. Fire barrier material shall be provided in annular spaces between sleeves and piping or tubing where piping or tubing penetrates floors or partitions that have a fire rating of one hour or greater.

B. Material shall be UL classified as a through penetration fill, void or cavity material and shall be capable of passing a 4 hour fire test per ASTM E-814.

C. Material shall be installed in strict accordance with the manufacturers instructions.

2.11 SAFING MATERIAL

A. Safing material shall be installed in annular spaces between sleeve and pipe or tubing where sleeve and pipe or tubing penetrate partitions that are designated as smoke

separations.

B. Material shall be mineral wool designed for hand packing. Material shall have an ASTM E84 rating of flame spread B10, fuel contributed B0, smoke developed B0 and shall be rated non-combustible per ASTM E136.

PART 3 - EXECUTION

3.1 EXCAVATING AND BACKFILLING UNDER BUILDING SLABS

A. Before excavating or trenching, the Contractor shall locate and stake out existing underground utilities which are to remain and may be adversely affected by the work. Work shall be performed in a manner to avoid damaging the existing utilities. The Contractor shall repair or replace any utilities damaged by him.

B. The Contractor shall do all excavating, trenching and backfilling for the work of this Division. The Contractor shall work around or remove as necessary all obstructions. Bottoms of trenches shall be tamped hard. Bell holes shall be excavated to insure that pipe rests on solid earth for its entire length.

C. Backfilling trenches for piping under structural pile supported slabs shall be done by hand, Fill shall be "walked" or hand tamped on each side of pipe to provide compaction that will hold the piping in alignment. The remainder of the trench may be backfilled by hand or approved mechanical means. Care shall be taken during tamping to keep piping in alignment.

D. The Contractor shall remove any water which may be found or may accumulate in the trenches and shall perform all work necessary to keep them clear of water while the work is in progress, or as may be required for inspections.

3.2 EXCAVATING AND BACKFILLING OUTSIDE BUILDING SLAB

A. Clearing and Grubbing:

1. The Contractor shall clear and grub the surface areas and remove all surface materials of whatever nature encountered, except where jacking and boring is required, over the line of and to either side of the trenches, the site of other structures and all other areas where the piping systems are to be installed.
2. All plants, and surfacing that occur in the area of the excavation shall be carefully removed and maintained in an area where they will not be damaged. After the excavations are filled, the plants, and surfacing shall be replaced as directed. All existing sidewalks, driveways, or other cement or asphalt surfaces which are to remain and have been damaged during excavating shall be repaired to match the adjacent work in material and finish.

B. TRENCHES

1. Trenches shall be dug so that pipe can be laid to the alignment, depth and slope indicated. Excavation shall be only so far in advance of the pipe laying as to reveal any obstructions, but never more than 100' in advance of the pipe installation unless specifically approved by the Architect.
2. Trenches shall be graded such that each section of pipe will rest upon the trench bottom for the full length of its barrel. Provide bell holes at each joint as required for this purpose.
3. Trenching shall be such that the pipe will have no less than 30" of minimum cover unless specifically graded with less cover on the drawings. Depth of cover shall be measured from finished grade to the top of the barrel of the pipe.
4. Where sub-surface obstructions are encountered, the Contractor will be permitted to lay pipe above the obstruction, if the minimum cover required can be obtained

while providing a cushion, between the bottom of the pipe and the top of the obstruction, at least 6" thick. Where this minimum cover cannot be obtained, the Contractor will be required to lay pipe under the obstruction provided that the change in elevations will not adversely affect the minimum slope (if any). The Contractor will receive no additional compensation for constructing the line in this manner.

5. Where necessary to protect workmen, the work, or adjacent property, the Contractor shall provide necessary sheeting and/or shoring.
6. Underground cables, power poles, etc., along the line of work shall be protected and sufficient barricades, lanterns, etc., shall be provided for the protection of the public.
7. When excavation is carried below or beyond the specified grade, the space shall be filled with river sand, and properly compacted up to specified grade. No claim for additional compensation shall be made for backfilling excess excavations.
8. If, in the opinion of the Architect, the soil at the bottom of the trench is such that it cannot be properly graded, or that it will not properly support the pipe, the Contractor shall excavate below the specified grade as directed by the Architect. Wherever excavation is carried below the specified grade, at the direction of the Architect, the space shall be filled with river sand, and properly compacted up to specified grade. Cost of such excavation and backfill shall be agreed upon in advance as a Change Order to the Contract.
9. Trenches shall be of such extra width, when required, to permit the convenient placing of supports, sheeting, shoring and bracing and the installation of valves, fittings, and thrust blocking.

C. DEWATERING

1. The Contractor shall remove any water which may be found or may accumulate in the trenches and excavations and shall perform the work necessary to keep them clear of water while the work is in progress, or as may be required for inspections.
2. The Contractor must use due vigilance and care so that no water originating on his work, or due to his work, which he is obligated to handle and dispose of under his contract, shall discharge or be discharged upon the work or into the trenches of another contract, unless by mutual agreement of parties affected. Should any dispute arise from this cause, the matter shall be referred to the Architect for final settlement. Nothing in this Section is to be construed as preventing the reasonable use by any Contractor of any ditch, canal or swale which is designed and used for drainage.
3. Ditches or swales parallel with the trench must be maintained unobstructed. When necessary, a proper platform shall be built over them and the excavated dirt placed thereon so as to permit the free passage of all drainage water.

D. BEDDING AND BACKFILL

1. Bedding and backfill material shall be river sand.
2. Backfilling shall not begin until the pipe work to be covered has been inspected by the Architect. The Architect reserves the right to order any trench backfilled at any time after installation of pipe, if, in his opinion, the particular trench remaining open constitutes a public nuisance.
3. The Contractor shall be responsible for settlement of backfill in trenches excavated for work of this Division. Trenches shall be refilled as often as necessary to bring them back to required or original grades.
4. Bedding under pipe - Trenches shall be bedded by hand. A 6" layer of river sand shall be placed in the trench and compacted and graded prior to installing the pipe. After the pipe is installed river sand shall be carefully placed in 3" layers on both sides of the pipe and compacted and graded by hand. The sand shall be deposited in the trench for its full width on each side of the pipe, fittings and appurtenances, simultaneously.

a. Backfilling to 1' above pipe - From the centerline of the pipe, fittings and appurtenances to a depth of 1' above the top of the barrel of the pipe, the trench shall be backfilled by hand or approved mechanical means with river sand. The Contractor shall use special care in placing this portion of the backfill so as to avoid injuring or moving the pipe. This part of the backfill shall be compacted by method approved by the Architect.

b. Backfilling to grade - From 1' above the barrel of the pipe up to grade, the Contractor shall fill the trench with river sand. Backfill shall be compacted by methods specified in DIVISION 2 - SITEWORK. Where sheeting and bracing are removed from the trench or excavation as backfilling progresses, care shall be taken to insure that voids left by the withdrawn timbers are carefully and thoroughly compacted.

3.3 DISPOSAL OF EXCESS EXCAVATED MATERIAL

A. Excess fill taken from excavations may be used as fill for the site in general, but may not be used as fill under slabs, sidewalks, pavements, drives, etc., provided same will readily compact, is free of debris, organic or other injurious matter, and is acceptable to the Architect.

B. Any surplus earth which may be left at the site after all site grading and excavations have been completely filled shall, unless otherwise provided, be regarded as the property of the Contractor, and shall be removed as soon as possible at his expense.

3.4 SUB-SURFACE OBSTRUCTIONS

A. Care must be taken not to disturb, injure or remove any pipes, cables, conduits or other underground structures or utilities. If necessary, the Contractor shall, at his own expense, shore-up and protect underground piping, conduit structures or utilities which may be endangered during the work and shall maintain such structures and utilities in operation.

B. In the event subsurface structures, pipes, cables, conduits or utilities are broken or damaged in the execution of the work, the Contractor shall notify the proper authorities and shall make repairs, at his own expense, and to the satisfaction of the Architect and authorities involved. The Contractor shall be responsible for any damage to persons or property caused by such breaks.

C. The Contractor shall uncover, sub-surface obstructions in advance of construction so that the method of avoiding same may be determined before pipe laying reaches the obstructions.

D. The Architect will, in all cases, be the judge of the necessity of expedience of any change or rearrangement of any underground structures which may interfere with the construction of the work under this Section.

3.5 SHEETING AND SHORING

A. Sheeting and shoring shall be placed in excavations and trenches as required to suit the ground conditions and to properly and safely support the excavations and trench walls and any adjacent structures.

B. Placement of the sheeting and shoring in the trench shall not restrict the excavation and trench width specified in other Sections.

C. Sheeting and shoring for excavations and trenches less than five feet in depth may be of wood. Wood indicated to remain in excavations and trenches shall be treated type. Sheeting and shoring for excavations and trenches greater than five feet in depth shall be of steel construction.

D. Unless otherwise instructed by the Architect, all wood sheeting, shoring and bracing shall be cut-off at an elevation of 24" below finished grade. The lower portion of the sheeting and bracing below grade shall remain in the ground. If instructed by the Architect to remove the wood or steel sheeting and shoring it shall not be removed until backfilling is completed.

3.6 SURFACE OBSTRUCTIONS

A. The Contractor shall be responsible for the integrity of all poles, culverts, posts, fences, trees, walls, buildings or any other structures, property or objects along the line of his work and shall shore up, support and protect them when necessary. Any damage caused by or through his work shall, within a reasonable time, be repaired and/or replaced and restored to the same condition as existed before his work, without any additional compensation.

3.7 CROSSING OF DITCHES

A. Natural drainage ditches or swales shall not be unreasonably blocked or obstructed or prevented from carrying their customary drainage and shall be replaced by the Contractor in as good condition as they were originally, without additional compensation.

B. The Contractor shall be responsible for any damage of any kind resulting from interference with or obstruction of any drainage ditches or other waterway.

3.8 THRUST BLOCKS

A. Thrust blocks shall be provided for underground water mains 4" and larger and sewer force mains at each change of direction 113 degrees or greater, at tees, tapping sleeves, hydrants, and at dead ends. Thrust blocks shall be constructed of concrete or timbers. Thrust blocks shall be of sufficient size to resist the force resulting from the flow of water through the type of fitting being blocked.

B. Timber thrust blocks shall be constructed by setting treated 2 x 12 planks against the undisturbed soil of the trench wall and wedging appropriate sized treated blocking between the planks and the fitting. An adequate quantity of planks shall be placed against undisturbed soil to sufficiently distribute the forces so that the bearing value of the soil will resist the reaction of the fitting.

C. Concrete mix for thrust blocks shall be 1:2 1/2:5. Concrete in thrust blocks shall not cover any pipe joints or interfere in any way with future maintenance of the joints.

D. Thrust blocks will not be required on lines where restrained joints are installed per NFPA-24.

3.9 PIPING SYSTEMS--COMMON REQUIREMENTS

A. General: Install piping as described below, except where system Sections specify otherwise. Individual piping system specification Sections in Division 23 specify piping installation requirements unique to the piping system.

B. General Locations and Arrangements: Drawings (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, except where deviations to layout are approved on coordination drawings.

C. Install piping at indicated slope.

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

E. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

F. Install piping free of sags and bends.

G. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

H. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

I. Install piping to allow application of insulation plus 1-inch clearance around insulation.

J. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

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

L. Install couplings according to manufacturer's printed instructions.

M. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:

N. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.

O. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.

P. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.

Q. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.

1. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.

R. Sleeves are not required for core drilled holes.

S. Permanent sleeves are not required for holes formed by PE plastic (removable) sleeves.

T. Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.

U. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, concrete floor and roof slabs, and where indicated.

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

1. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.
2. Build sleeves into new walls and slabs as work progresses.
3. Install large enough sleeves to provide 1/4-inch (6-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

4. Steel Pipe Sleeves: For pipes smaller than 6 inches (150 mm).
5. Steel Sheet-Metal Sleeves: For pipes 6 inches (150 mm) and larger that penetrate gypsum-board partitions.
6. Cast-Iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Flashing is specified in Division 7 Section "Flashing and Sheet Metal."
   1) Seal space outside of sleeve fittings with nonshrink, nonmetallic grout.
7. Except for below-grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants specified in Division 7 Section "Joint Sealants."

W. Above Grade, Exterior Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.

1. Install steel pipe for sleeves smaller than 6 inches.
2. Install cast-iron wall pipes for sleeves 6 inches and larger.
3. Assemble and install mechanical seals according to manufacturer's printed instructions.

X. Below Grade, Exterior Wall, Pipe Penetrations: Install cast-iron wall pipes for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.

Y. Below Grade, Exterior Wall, Pipe Penetrations: Install ductile-iron wall penetration system sleeves according to manufacturer's printed installation instructions.

Z. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material. Firestopping materials are specified in Division 7 Section "Firestopping."

AA. Verify final equipment locations for roughing in.

BB. Refer to equipment specifications in other Sections for roughing-in requirements.

CC. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.

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

1. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
2. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."
3. Brazed Joints: Construct joints according to AWS "Brazing Manual" in the "Pipe and Tube" chapter.
4. 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 inside diameter. Join pipe fittings and valves as follows:
   a) Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
   b) Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).
   c) Align threads at point of assembly.
   d) Tighten joint with wrench. Apply wrench to valve end into which pipe is

being threaded.

e) Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

5. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.
6. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
7. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:
   a) Comply with ASTM F 402 for safe handling of solvent-cement and primers.
   b) Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235 and ASTM D 2661.
   c) Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM D 2846 and ASTM F 493.
   d) Poly(Vinyl Chloride) (PVC) Pressure Application: ASTM D 2672.
   e) Poly(Vinyl Chloride) (PVC) Non-Pressure Application: ASTM D 2855.
   f) PVC to ABS (Non-Pressure) Transition: Procedure and solvent cement described in ASTM D 3138.
8. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.
9. Plain-End Pipe and Fittings: Butt joining.
   a) Plain-End Pipe and Socket-Type Fittings: Socket joining.

EE. Piping Connections: Except as otherwise indicated, make piping connections as specified below.

1. Install unions in piping 2 inches and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch (50-mm) or smaller threaded pipe connection.
2 Install flanges in piping 2-1/2 inches and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
3. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.10 EQUIPMENT INSTALLATION--COMMON REQUIREMENTS

A. Install equipment to provide the maximum possible headroom where mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.

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

D. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

E. Install equipment giving right-of-way to piping systems installed at a required slope.

3.11 SPECIAL CONDITIONS

A. No piping, ducts or other mechanical equipment foreign to electrical equipment shall pass through or above spaces dedicated to panelboards, distribution panels, switchboards, and battery charging panels. Work shall conform with NFPA 70, Article 384.

3.12 PAINTING AND FINISHING

A. Damage and Touch Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.13 COORDINATE CONCRETE WORK WITH DIVISION 3. ERECTION OF METAL SUPPORTS AND ANCHORAGE

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

B. Field Welding: Comply with AWS D1.1 "Structural Welding Code--Steel."

3.14 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.15 DEMOLITION

A. Disconnect, demolish, and remove work specified under Division 23 and as indicated.

B. Where pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.

C. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.

D. Abandoned Work: Cut and remove buried pipe abandoned in place, 2 inches (50 mm) beyond the face of adjacent construction. Cap and patch surface to match existing finish.

E. Removal: Remove indicated equipment from the Project site.

F. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

G. In the removal of existing fixtures, equipment, ductwork and/or piping, the contractor shall insure that the portion of any system which remains continues to be operable.

H. Routings indicated for existing mechanical systems approximate. The contractor shall field verify existing conditions prior to ordering equipment or materials and shall make field adjustments as required.

3.16 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of the trades involved.

B. Repair cut surfaces to match adjacent surfaces.

C. Field cut openings shall be located to avoid the reinforcing. Locations shall be subject to approval of engineer.

D. No structural members shall be field cut or pierced without the written approval of the engineer.

3.17 GROUTING

A Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms for placement of grout, as required.

D. Avoid air entrapment when placing grout.

E. Place grout to completely fill equipment bases.

F. Place grout on concrete bases to provide a smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's printed instructions.

3.18 ACCESS DOORS

A. Equipment which may require constant or periodic operation or adjustment such as but not limited to valves, water hammer arrestors, cleanouts, automatic, smoke and fire dampers, damper operators, mixing boxes, variable volume equipment, steam traps, plumbing traps, plumbing fixture connections, etc., located in or above inaccessible ceilings, walls, or chases shall have hinged metal access doors as required by type of construction.

B. Minimum door size shall be 8" x 8". Doors shall be of sufficient size to adequately service, repair, replace or inspect the equipment.

END OF SECTION 22 00 05

SECTION 22 00 10 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract including Scope of Work Section apply to this Section.

1.2 SUMMARY

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

1.3 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."

1.4 PERFORMANCE REQUIREMENTS

A. Provide 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.

1.5 SUBMITTALS

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

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Pipe Hangers:
   a. Grinnell Corp.
   b. National Pipe Hanger Corp.
   c. Piping Technology & Products, Inc.
2. Channel Support Systems:
   a. Grinnell Corp.; Power-Strut Unit.
   b. National Pipe Hanger Corp.
   c. Unistrut Corp.
3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. Pipe Shields, Inc.

4. Powder-Actuated Fastener Systems:
a. Gunnebo Fastening Corp.
b. Hilti, Inc.
c. ITW Ramset/Red Head.
d. Masterset Fastening Systems, Inc.

2.2 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 piping and equipment that will not have field-applied finish.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

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

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
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 with vapor barrier.
2. Material for Hot Piping: ASTM C 552, Type I cellular glass.
3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 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

3.1 HANGER AND SUPPORT APPLICATIONS

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

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

C. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.

1. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
2. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
4 Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 with steel pipe base stanchion support and cast-iron floor flange.

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 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, 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. Steel Weldless 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. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

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

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
3. 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.

H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2 Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3 Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

3.2 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. 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. 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.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. 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.

E. 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.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely

cured. Install fasteners according to manufacturer's written instructions.

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

H. 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.

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

J. 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.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.9.
2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 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.

3.4 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.

3.5 ADJUSTING

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

3.6 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 22 00 10

SECTION 22 00 20 - VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section apply to this Section.

1.2 SUMMARY

A. This Section includes general duty valves common to several mechanical piping systems.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Special purpose valves are specified in Division 15 piping system Sections.
2. Valve tags and charts are specified in Division 15 Section "Mechanical Identification."

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

C. Maintenance data for valves to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions on adjusting, servicing, disassembling, and repairing.

1.4 QUALITY ASSURANCE

A. Single-Source Responsibility: Comply with the requirements specified in Division 1 Section "Materials and Equipment," under "Source Limitations" Paragraph.

B. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

C. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set globe and gate valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use a sling to handle large valves. Rig to avoid damage to exposed parts. Do not use handwheels and stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Gate Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve Corporation.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.
2. Ball Valves:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Hammond Valve Corporation.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.
3. Globe Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve Corporation.
   c. NIBCO Inc.
   d. Stockham Valves & Fittings, Inc.
5. Butterfly Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Grinnell Corp.
   c. Hammond Valve Corporation.
   d. NIBCO Inc.
   e. Stockham Valves & Fittings, Inc.
6. Swing Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. Hammond Valve Corporation.
   c. Milwaukee Valve Company, Inc.

d. NIBCO Inc.
e. Stockham Valves & Fittings, Inc.

7. Lift Check Valves:
   a. Crane Company; Valves and Fitting Division.
   b. NIBCO Inc.
   c. Stockham Valves & Fittings, Inc.

2.2 BASIC, COMMON FEATURES

A. Design: Rising stem or rising outside screw and yoke stems, except as specified below.

1. Nonrising stem valves may be used only where headroom prevents full extension of rising stems.

B. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

C. Sizes: Same size as upstream pipe, unless otherwise indicated.

D. Operators: Use specified operators and handwheels, except provide the following special operator features:

1. Handwheels: For valves other than quarter turn.
2. Lever Handles: For quarter-turn valves 6 inches and smaller.
3. Chain-Wheel Operators: For valves 4 inches and larger, installed 96 inches or higher above finished floor elevation.

E. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

F. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

G. Threads: ASME B1.20.1.

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

I. Solder Joint: ASME B16.18.

1. Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Gate Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi cold working pressure (CWP), or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and bonnet, solid-bronze wedge, copper-silicon alloy rising stem, teflon-impregnated packing with bronze packing nut, threaded or soldered end

connections; and with aluminum or malleable-iron handwheel.

B. Gate Valves, 3 Inches and Larger: MSS SP-70, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bonnet, solid cast-iron wedge, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with 2-piece packing gland assembly, flanged end connections; and with cast-iron handwheel.

2.4 BALL VALVES

A. Ball Valves, 4 Inches and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:

Operator: Vinyl-covered steel lever handle.
1. Stem Extension: For valves installed in insulated piping.
2. Memory Stop: For operator handles.

2.5 GLOBE VALVES

A. Globe Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or teflon disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

B. Globe Valves, 3 Inches and Larger: MSS SP-85, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted bonnet with bronze fittings, renewable bronze seat and disc, brass-alloy stem, outside screw and yoke, teflon-impregnated packing with cast-iron follower, flanged end connections; and with cast-iron handwheel.

2.6 BUTTERFLY VALVES

A. Butterfly Valves: MSS SP-67, 200-psi CWP, 150-psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, wafer, lug, or grooved style:

1. Disc Type: Aluminum bronze.
2. Operator for Sizes 2 Inches to 6 Inches: Standard lever handle.

2.7 CHECK VALVES

A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections:

B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc,

flanged or grooved end connections.

C. Lift Check Valves: Class 125, ASTM B 62 bronze body and cap (main components), horizontal or vertical pattern, lift-type, bronze disc or Buna N rubber disc with stainless-steel holder threaded or soldered end connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

C. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the center of the pipe.

F. Install valves in a position to allow full stem movement.

G. Installation of Check Valves: Install for proper direction of flow as follows:

1. Swing Check Valves: Horizontal position with hinge pin level.
2. Lift Check Valve: With stem upright and plumb.

3.3 SOLDERED CONNECTIONS

A. Cut tube square and to exact lengths.

B. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket.

C. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

D. Open gate and globe valves to fully open position.

E. Remove the cap and disc holder of swing check valves having composition discs.

F. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

G. Apply heat evenly to outside of valve around joint until solder melts on contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.4 THREADED CONNECTIONS

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

B. Align threads at point of assembly.

C. Apply appropriate tape or thread compound to the external pipe threads, except where dry seal threading is specified.

D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.5 FLANGED CONNECTIONS

A. Align flange surfaces parallel.

B. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.6 VALVE END SELECTION

A. Select valves with the following ends or types of pipe/tube connections:

1. Copper Tube Size, 2-1/2 Inches and Smaller: Solder ends, except provide threaded ends for heating hot water.

2. Steel Pipe Sizes, 2-1/2 Inches and Smaller: Threaded or grooved end.
3. Steel Pipe Sizes, 3 Inches and Larger: Grooved end or flanged.

3.7 APPLICATION SCHEDULE

A. General Application: Use gate, ball, and butterfly valves for shutoff duty; ball, and butterfly for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.

B. Heating Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze or cast-iron body to suit piping system.
2 Ball Valves: Class 150, 600-psi CWP, with stem extension and memory stop.
3. Globe Valves: Class 150, bronze or cast-iron body to suit piping system, and bronze disc.
4 Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or epoxy-coated ductile iron disc; EPDM or Buna N sleeve and stem seals.
5. Bronze Swing Check: Class 150, with composition seat.
6. Check Valves: Iron swing, or lift type, as indicated. Swing check shall be Class 150 with bronze seat ring.

C. Chilled-Water Systems: Use the following valve types:

1. Gate Valves: Class 150, bronze body; or Class 125, cast-iron body.
2 Ball Valves: Class 150, 600-psi CWP, with stem extension and memory stop.
3. Globe Valves: Class 125, bronze body with bronze or teflon disc; or Class 125, cast-iron body.
4. Butterfly Valves: Nickel-plated ductile iron, aluminum bronze, or elastomer-coated ductile iron disc; EPDM sleeve and stem seals.
5. Check Valves: Class 125, bronze body swing check with rubber seat; Class 125, cast-iron body swing check; Class 125, cast-iron body wafer check; or Class 125, cast-iron body lift check.

3.8 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION 22 00 20

SECTION 22 00 22 - METERS AND GAGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract including Scope of Work Section apply to this Section.

1.2 SUMMARY

A. This Section includes meters and gages for mechanical systems.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Liquid-in-Glass Thermometers:
   a. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
   b. Ernst Gage Co.
   c. Marsh Bellofram.
   d. Palmer Instruments, Inc.
   e. Trerice: H. O. Trerice Co.
   f. Weiss Instruments, Inc.
   g. Winter's Thermogauges, Inc.
2. Pressure Gages:
   a. AMETEK, Inc.; U.S. Gauge Div.
   b. Dresser Industries, Inc.; Instrument Div.; Ashcroft Commercial Sales Operation.
   c. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
   d. Ernst Gage Co.
   e. Marsh Bellofram.
   f. Noshok, Inc.
   g. Trerice: H. O. Trerice Co.
   h. Weiss Instruments, Inc.
   i. WIKA Instruments Corp.
   j. Winter's Thermogauges, Inc.
3. Test Plugs:
   a. Flow Design, Inc.
   b. MG Piping Products Co.
   c. National Meter.
   d. Peterson Equipment Co., Inc.
   e. Sisco Manufacturing Co.

f. Trerice: H. O. Trerice Co.
g. Watts Industries, Inc.; Water Products Div.

2.2 THERMOMETERS, GENERAL

A. Scale Range: Temperature ranges for services listed are as follows:

B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Description: ASTM E 1.

B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, 9 inches long.

C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.

D. Tube: Red or blue reading, organic-liquid filled with magnifying lens.

E. Scale: Satin-faced nonreflective aluminum with permanently etched markings.

F. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 SEPARABLE SOCKETS

A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.

1. Material: Brass, for use in copper piping.
2. Material: Steel, for use in steel piping.
3. Extension-Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation. Omit extension neck for sockets for piping not insulated.
4. Insertion Length: To extend to one-third of diameter of pipe.
5. Cap: Threaded, with chain permanently fastened to socket.
6. Heat-Transfer Fluid: Oil

2.5 THERMOMETER WELLS

A. Description: Fitting with protective well for installation in threaded pipe fitting to hold test thermometer.

1. Material: Brass, for use in copper piping.
2. Material: Steel, for use in steel piping.
3. Extension-Neck Length: Nominal thickness of 2 inches but not less than thickness of insulation. Omit extension neck for wells for piping not insulated.
4. Insertion Length: To extend to one-third of diameter of pipe.
5. Cap: Threaded, with chain permanently fastened to socket.
6. Heat-Transfer Fluid: Oil or graphite.

2.6 PRESSURE GAGES

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 A, plus or minus 1 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.

2.7 PRESSURE-GAGE 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.

2.8 TEST PLUGS

A. Description: Nickel-plated, brass-body test plug in NPS 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 gage.

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

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

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

PART 3 - EXECUTION

3.1 METER AND GAGE INSTALLATION, GENERAL

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

3.2 THERMOMETER INSTALLATION

A. Install thermometers and adjust vertical and tilted positions.

B. Install in the following locations:

1. Inlet and outlet of each hydronic boiler and chiller.
2. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.

C. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending a minimum of 2 inches (50 mm) into fluid.
2. Install with socket extending to one-third of diameter of pipe.
3. Install with socket extending to center of pipe.
4. Fill sockets with oil or graphite and secure caps.

D. Install thermometer wells in vertical position in piping tees where test thermometers are indicated.

1. Install with stem extending to one-third of diameter of pipe.
2. Fill wells with oil or graphite and secure caps.

3.3 PRESSURE-GAGE INSTALLATION

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

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

1. Discharge of each pressure-reducing valve.
2. Chilled-water inlets and outlets of chillers.

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

D. Install pressure-gage needle valve and snubber in piping to pressure gages.

3.4 CONNECTIONS

A. Make electrical connections to power supply and electrically operated meters and devices.

B. Install electrical connections for power and devices.

C. Electrical power, wiring, and connections are specified in Division 16 Sections.

3.5 ADJUSTING AND CLEANING

A. Calibrate gages according to manufacturer's written instructions, after installation.

B. Adjust faces of gages to proper angle for best visibility.

C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 22 00 22

SECTION 230593 - TESTING ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes testing, adjusting, and balancing HVAC systems to produce design objectives, including the following:

1. Balancing airflow and water flow within distribution systems, including submains, branches, and terminals, to indicated quantities according to specified tolerances.
2. Adjusting total 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.

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.

1.3 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 submains, branches, and terminals, according to design quantities.

C. 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.

D. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

E. Report Forms: Test data sheets for recording test data in logical order.

F. 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.

G. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

H. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

I. 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.

J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

K. Test: A procedure to determine quantitative performance of a system or equipment.

L. Testing, Adjusting, and Balancing Agent: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

M. AABC: Associated Air Balance Council.

N. AMCA: Air Movement and Control Association.

O. CTI: Cooling Tower Institute.

P. NEBB: National Environmental Balancing Bureau.

Q. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS

A. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

1.5 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by either AABC or NEBB.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify the testing, adjusting, and balancing field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
2. Certify that the testing, adjusting, and balancing team complied with the approved testing, adjusting, and balancing plan and the procedures specified and referenced in this Specification.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC's "National Standards for Testing, Adjusting, and Balancing."

D. Testing, Adjusting, and Balancing Reports: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC national standards.

F. Instrumentation Type, Quantity, and Accuracy: As described in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

G. Instrumentation Calibration: Calibrate instruments at least every 6 months or more frequently if required by the instrument manufacturer.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire testing, adjusting, and balancing period. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

1.7 COORDINATION

A. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Test and Balancer under requirements of the Contract Documents.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the 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.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine equipment performance data, including fan and pump 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 the 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.

D. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

E. Examine system and equipment test reports.

F. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

G. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

H. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

I. Examine strainers for clean screens and proper perforations. This shall be the work of the mechanical contractor and controls subcontractor.

J. Examine 2-way valves for proper installation for their intended function of diverting or mixing fluid flows. This shall be the work of the mechanical contractor and controls subcontractor.

K. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping. This shall be the work of the mechanical contractor and controls subcontractor.

L. Examine equipment for installation and for properly operating safety interlocks and controls. This shall be the work of the mechanical contractor and controls subcontractor.

M. Examine automatic temperature system components to verify the following: This shall be the work of the mechanical contractor and controls subcontractor.

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

N. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Mechanical contractor shall complete system readiness checks and prepare readiness report. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.
5. Isolating and balancing valves are open and control valves are operational.
6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
7. Windows and doors can be closed so design conditions for system operations can be met.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC national standards and this Section.

B. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

C. Cut insulation, ducts, pipes, 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 the insulation Specifications for this Project.

D. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

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. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

C. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Verify that motor starters are equipped with properly sized thermal protection.

F. Check dampers for proper position to achieve desired airflow path.

G. Check for airflow blockages.

H. Check condensate drains for proper connections and functioning.

I. Check for proper sealing of air-handling unit components.

3.5 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the 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.

2. Measure static pressure across each air-handling unit component.

a) Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Adjust fan speed higher or lower than design with the approval of the Architect. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure no overload will occur. Measure amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design 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 submains 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

6. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

7. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

8. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

9. Record the final fan performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance systems similar to constant-volume air systems.

2. Set terminal units and supply fan at full-airflow condition.

3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

4. Readjust fan airflow for final maximum readings.

5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.

6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

   a.) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.

3. Set terminal units at full-airflow condition.

4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.

7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.6 FUNDAMENTAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at design flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 HYDRONIC SYSTEMS' BALANCING PROCEDURES

A. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than design flow.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

1. Determine the balancing station with the highest percentage over design flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.
3. Record settings and mark balancing devices.

F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Motor horsepower rating.
2. Motor rpm.
3. Efficiency rating if high-efficiency motor.
4. Starter thermal-protection-element rating.

3.9 CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of design flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.
2. Condenser water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kW.
5. The kW input if factory-installed instrumentation is furnished for measuring kW.
6. Capacity: Calculate in tons of cooling.
7. Air-Cooled Chillers: Verify condenser-fan rotation and record fan data, including number of fans and entering- and leaving-air temperatures.

3.10 BOILERS

A. Measure entering- and leaving-water temperatures and water flow.

3.11 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Wet-bulb temperatures of entering and leaving air for cooling coils designed for less than 13,000 cfm.
6. Airflow.
7. Air pressure drop.

B. Electric-Heating Coils: Measure the following data for each coil:

1. Nameplate data.
2. Airflow.
3. Voltage and amperage input of each phase at full load and verify and report the number of stages.
4. Calculated kW at full load.

3.12 TEMPERATURE TESTING

A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure outside-air, wet- and dry-bulb temperatures.

3.13 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. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as damper and valve operators.

F. Verify 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. Confirm interaction of electrically operated switch transducers.

H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

L. Control Contractor shall verify all temperature control devices for proper operation before any balancing work is started.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
1. Water Flow Rates (GPM): +/- 5% (for FLOW RATES not PRESSURE READINGS
2. AIR(CFM):
   a. AHU's +0% to +5%(tested with dirty filters, and with VFD drive sheaves adjusted for full flow operation at 60Hz, if required)
   b. Diffusers (and spaces that contain them): refer to AABC or NEBB standards.
   c. Outdoor Air: +/-5%(ducted OA. +/-10%(non-ducted OA
   d. Exhaust: +/-10%
3. Temperatures:
   a. Thermostats: +/-2^{o}F
   b. Temperatures DB/WB on Coils: +/-1 ^{o}F of the average readings taken on one(1) square foot increments.
   c. Water Temperatures: +/-1 ^{o}F
4. Pressures:
   a. Air: +/-" WC below 1.0" WC taken with inclined manometer
   b. Water:+/-1 psig taken with Bourdon Gauge with scale 0 to 100 psig
   c. Water: +/-5' taken with digital pressure differential meter

3.15 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in 3-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.

C. Include a list of the instruments used for procedures, along with proof of calibration.

D. Final Report Contents:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.

E. General Report Data: In addition to the form titles and entries, include the following data in the

final report, as applicable:

1. Title page.
2. Name and address of testing, adjusting, and balancing Agent.
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 testing, adjusting, and balancing Agent who certifies the report.
10. Summary of contents, including the following:
    a) Design versus final performance.
    b) Notable characteristics of systems.
    c) Description of system operation sequence if it varies from the Contract Documents.
11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer, type size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from design values.
14. Test conditions for fans and pump performance forms, including the following:
    a) Settings for outside-, return-, and exhaust-air dampers.
    b) Conditions of filters.
    c) Cooling coil, wet- and dry-bulb conditions.
    d) Face and bypass damper settings at coils.
    e) Fan drive settings, including settings and percentage of maximum pitch diameter.
    f) Inlet vane settings for variable-air-volume systems.
    g) Settings for supply-air, static-pressure controller.
    h) Other system operating conditions that affect performance.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
    a) Unit identification.
    b) Location.
    c) Make and type.
    d) Model number and unit size.
    e) Manufacturer's serial number.
    f) Unit arrangement and class.
    g) Discharge arrangement.
    h) Sheave make, size in inches, and bore.
    i) Sheave dimensions, center-to-center and amount of adjustments in inches.
    j) Number of belts, make, and size.
    k) Number of filters, type, and size.
2. Motor Data: Include the following:
    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.
3. Test Data: Include design and actual values for the following:
    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) Filter static-pressure differential in inches wg.

f) Preheat coil static-pressure differential in inches wg.
g) Cooling coil static-pressure differential in inches wg.
h) Heating coil static-pressure differential in inches wg.
i) Outside airflow in cfm.
j) Return airflow in cfm .
k) Outside-air damper position.
l) Return-air damper position.
m) Vortex damper position.

G. Apparatus-Coil Test Reports: For apparatus coils, include the following:

1. Coil Data: Include the following:
   a) System identification.
   b) Location.
   c) Coil type.
   d) Number of rows.
   e) Fin spacing in fins per inch.
   f) Make and model number.
   g) Face area in sq. ft..
   h) Tube size in NPS .
   i) Tube and fin materials.
   j) Circuiting arrangement.
2. Test Data: Include design and actual values for the following:
   a) Airflow rate in cfm.
   b) Average face velocity in fpm.
   c) Air pressure drop in inches wg.
   d) Outside-air, wet- and dry-bulb temperatures in deg F.
   e) Return-air, wet- and dry-bulb temperatures in deg F.
   f) Entering-air, wet- and dry-bulb temperatures in deg F.
   g) Leaving-air, wet- and dry-bulb temperatures in deg F.
   h) Water flow rate in gpm.
   i) Water pressure differential in feet of head or psig.
   j) Entering-water temperature in deg F.
   k) Leaving-water temperature in deg F.
   l) Refrigerant expansion valve and refrigerant types.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data: Include the following:
   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: Include the following:
   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: Include design and actual values for the following:
   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.

I. Round, and Rectangular Duct Traverse Reports:

1. Report Data: Include the following:
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) Design airflow rate in cfm .
h) Design velocity in fpm .
i) Actual airflow rate in cfm .
j) Actual average velocity in fpm .
k) Barometric pressure in psig .

J. Packaged Chiller Reports: For each chiller, include the following:
Mechanical contractor shall provide #4 and #5 in chillers start up log.

1. Unit Data: Include the following:
a) Unit identification.
b) Make and model number.
c) Manufacturer's serial number.
d) Refrigerant type and capacity in gal..
e) Starter type and size.
f) Starter thermal protection size.
2. Condenser Test Data: Include design and actual values for the following:
a) Refrigerant temperature in deg F .
b) Entering-water temperature in deg F.
c) Leaving-water temperature in deg F.
d) Entering-water pressure in feet of head or psig.
e) Water pressure differential in feet of head or psig.
3. Evaporator Test Reports: Include design and actual values for the following:
a) Refrigerant temperature in deg F.
b) Entering-water temperature in deg F.
c) Leaving-water temperature in deg F.
d) Entering-water pressure in feet of head or psig.
e) Water pressure differential in feet of head or psig.
4. Compressor Test Data: Include design and actual values for the following:
a) Make and model number.
b) Manufacturer's serial number.
c) Suction pressure in psig.
d) Suction temperature in deg F.
e) Discharge pressure in psig.
f) Discharge temperature in deg F.
g) Oil pressure in psig.
h) Oil temperature in deg F.
i) Voltage at each connection.
j) Amperage for each phase.
k) The kW input.
l) Crankcase heater kW.
m) Chilled water control set point in deg F.
n) Condenser water control set point in deg F.
o) Refrigerant low-pressure-cutoff set point in psig.

p) Refrigerant high-pressure-cutoff set point in psig.

5. Refrigerant Test Data: Include design and actual values for the following:
   a) Oil level.
   b) Refrigerant level.
   c) Relief valve setting in psig.
   d) Unloader set points in psig.
   e) Percentage of cylinders unloaded.
   f) Bearing temperatures in deg F.
   g) Vane position.
   h) Low-temperature-cutoff set point in deg F.

K. Pump Test Reports: For pumps, include the following data. Calculate impeller size by plotting the shutoff head on pump curves.

1. Unit Data: Include the following:
   a) Unit identification.
   b) Location.
   c) Service.
   d) Make and size.
   e) Model and serial numbers.
   f) Water flow rate in gpm.
   g) Water pressure differential in feet of head or psig.
   h) Required net positive suction head in feet of head or psig.
   i) Pump rpm.
   j) Impeller diameter in inches.
   k) Motor make and frame size.
   l) Motor horsepower and rpm.
   m) Voltage at each connection.
   n) Amperage for each phase.
   o) Full-load amperage and service factor.
   p) Seal type.
2. Test Data: Include design and actual values for the following:
   a) Static head in feet of head or psig.
   b) Pump shutoff pressure in feet of head or psig.
   c) Actual impeller size in inches.
   d) Full-open flow rate in gpm.
   e) Full-open pressure in feet of head or psig.
   f) Final discharge pressure in feet of head or psig.
   g) Final suction pressure in feet of head or psig.
   h) Final total pressure in feet of head or psig.
   i) Final water flow rate in gpm.
   j) Voltage at each connection.
   k) Amperage for each phase.

L. Boiler Test Reports: For boilers, include the following:

1. Unit Data: Include the following:
   a) Unit identification.
   b) Location.
   c) Service.
   d) Make and type.
   e) Model and serial numbers.
   f) Fuel type and input in Btuh.
   g) Number of passes.
   h) Ignition type.
   i) Burner-control types.
   j) Voltage at each connection.

k) Amperage for each phase.

2. Test Data: Include design and actual values for the following:
   a) Operating pressure in psig.
   b) Operating temperature in deg F.
   c) Entering-water temperature in deg F.
   d) Leaving-water temperature in deg F.
   e) Number of safety valves and sizes in NPS.
   f) Safety valve settings in psig.
   g) High-limit setting in psig.
   h) Operating-control setting.
   i) High-fire set point.
   j) Low-fire set point.
   k) Voltage at each connection.
   l) Amperage for each phase.
   m) Draft fan voltage at each connection.
   n) Draft fan amperage for each phase.
   o) Manifold pressure in psig.

M. Heating Coil Test Reports: For heating coils, include the following:

1. Heating Coil Data: Include the following:

a) Identification number.
b) Location.
c) Service.
d) Manufacturer.
e) Air flow, design and actual.
f) Water flow (gpm) or Steam mass flow rate (lbs per hour) design and actual.
g) Pressure drop water (feet w.g.) or steam (psid), design and actual.
h) Entering water or steam temperature, design and actual.
i) Leaving water or steam temperature, design and actual.
j) Entering air temperature, design and actual.
k) Leaving air temperature, design and actual.
l) Air quantity CFM design, and CFM actual.
m) Air pressure drop, design and actual.
n) Sensible Btu/hr design, and actual.

M. Instrument Calibration Reports: For instrument calibration, include the following:

1. Report Data: Include the following:
   a) Instrument type and make.
   b) Serial number.
   c) Application.
   d) Dates of use.
   e) Dates of calibration.

3.16 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION 23 05 93

SECTION 23 07 13 - MECHANICAL INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation semi-rigid and flexible duct insulation, blanket, board, and block 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 "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

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

B. 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.

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

1.4 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.

1.5 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.

1.6 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.

C. Coordinate installation and testing of electric heat tracing.

1.7 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

2.1 INSULATION MATERIALS

A. 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. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
3. 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 unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
   b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

B. 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.
3. Block Insulation: ASTM C 552, Type I.
4. Special_Shape Insulation: ASTM C 552, Type III.
5. Board Insulation: ASTM C 552, Type IV.

C. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.
2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.

D. Polyolefin Insulation: Unicellular polyethylene thermal plastic, preformed pipe insulation. Comply with ASTM C 534, Type I, except for density.

1. Adhesive: As recommended by insulation material manufacturer.

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

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

2.2 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. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.
2. PVC Jacket Color: White or gray.

D. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil-(0.5-mm-) 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.

E. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

2.3 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. (270 g/sq. m).

1. Tape Width: 4 inches (100 mm).

B. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch (0.18 mm) thick.

C. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

D. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel pin and washer manufactured for attachment to duct and plenum with adhesive. Pin lenght sufficient for insulation thickness indicated.

2.4 VAPOR RETARDERS

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

PART 3 EXECUTION

3.1 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.

3.2 PREPARATION

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

3.3 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 equipment, piping, and duct, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each 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, and tight longitudinal seams and end joints for duct. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

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

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- (75-mm-) 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 (100 mm) o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). 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 (100 mm) 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 (50 mm) below top of roof flashing.
4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

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

S. 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."

T. 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.

3.4 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 (25 mm), 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 (25 mm) 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 insulation sections are not available, apply 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.
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.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

E. 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 overcompress 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch (13-mm) staples, 1 inch (25 mm) 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- (150-mm-) 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 (150 mm) o.c.
8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 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. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) 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 cellular-glass block insulation of the same thickness as pipe insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), 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 cellular-glass 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 (25 mm) 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 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. 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.
4. 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.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

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

1. Follow manufacturer's written instructions for applying insulation.
2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

B. Apply insulation to flanges as follows:

1. Apply 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 sheet insulation of the same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

C. Apply insulation to fittings and elbows as follows:

1. Apply mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

D. Apply insulation to valves and specialties as follows:

1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to stainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.7 POLYOLEFIN INSULATION APPLICATION

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

1. Follow manufacturer's written instructions for applying insulation.
2. For split tubes, seal longitudinal seams and end joints with manufacturer's recommended adhesive.
3. For self-adhesive insulation, staple longitudinal seams after sealing. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

B. Apply insulation to flanges as follows:

1. Apply 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 polyolefin

sheet insulation of the same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

C. Apply insulation to fittings and elbows as follows:

1. Apply mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

D. Apply insulation to valves and specialties as follows:

1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
2. Apply cut segments of polyolefin pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to stainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.8 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 (150 mm) 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 (25 mm), 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 (25 mm) 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.

3.9 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 (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) 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.

3.10 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.

3.11 FIELD QUALITY CONTROL

A. Inspection: Owner will 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: 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:

C. 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.

D. 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.

E. 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 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. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.14 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic hot and recirculated hot water.

1. Operating Temperature: 60 to 140 deg F .
2. Insulation Material: **Mineral fiber**.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. **Copper** Pipe, all sizes: ¾" thick
4. Jacket: Foil and paper.
5. Vapor Retarder Required: No.
6. Finish: None.

B. Service: Domestic chilled water.

1. Operating Temperature: 35 to 60 deg F .
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. **Copper** Pipe, All sizes: ¾" thick.
4. Jacket: **Foil and paper**.
5. Vapor Retarder Required: **No**.
6. Finish: **None**.

C. Service: Condensate drain piping.

1. Operating Temperature: 35 to 75 deg F.
2. Insulation Material: Flexible elastomeric.
3. Insulation Thickness: ¾" thick
4. Field-Applied Jacket: None.
5. Vapor Retarder Required: Yes.
6. Finish: None.

D. Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled.

1. Operating Temperature: 35 to 120 deg F .
2. Insulation Material: Flexible elastomeric.
3. Insulation Thickness: ½" thick
4. Field-Applied Jacket: PVC P-trap and supply covers.
5. Vapor Retarder Required: No.
6. Finish: None.

E. Service: Chilled-water supply and return.

1. Operating Temperature: 35 to 75 deg F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:

a. **Steel** Pipe, all sizes: 1-1/2" thick
b. **Copper** Pipe, all sizes: 1-1/2" thick
4. Field-Applied Jacket: Foil and paper.
5. Vapor Retarder Required: Yes.
6. Finish: Painted.

F. Service: Refrigerant suction and hot-gas piping.

1. Operating Temperature: 35 to 50 deg F (2 to 10 deg C).
2. Insulation Material: Flexible elastomeric.
3. Insulation Thickness: Apply the following insulation thicknesses:
a. **Copper** Pipe, all sizes: ¾ " thick
4. Field-Applied Jacket: **None**.
5. Vapor Retarder Required: **No**.
6. Finish: **None**.

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

1. Operating Temperature: 100 to 200 deg F.
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:
a. **Steel** Pipe, 4" and smaller: 1" thick
b. **Steel** Pipe, 5" and larger: 1-1/2" thick.
4. Field-Applied Jacket: **Foil and paper**.
5. Vapor Retarder Required: **No**.
6. Finish: **Painted**.

3.15 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

B. Service: Refrigerant suction.

1. Operating Temperature: 35 to 50 deg F .
2. Insulation Material: **Flexible elastomeric**.
3. Insulation Thickness: Apply the following insulation thicknesses:
a. **Copper** Pipe, all sizes: ¾" thick.
4. Field-Applied Jacket: Aluminum.
5. Vapor Retarder Required: No.
6. Finish: None.

C. Service: Chilled-water supply and return.

1. Operating Temperature: 35 to 75 deg F .
2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:
a. **Steel** Pipe, all sizes: 2" thick.
b. **Copper** Pipe, all sizes: 2" thick.
4. Field-Applied Jacket: Aluminum.
5. Vapor Retarder Required: Yes.

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

1. Operating Temperature: 100 to 220 deg F.

2. Insulation Material: Mineral fiber.
3. Insulation Thickness: Apply the following insulation thicknesses:
   a. **Steel** Pipe, 4" and smaller: 1-1/2" thick
   b. **Steel** Pipe, 5" and larger: 2" thick.
4. Field-Applied Jacket: **Aluminum**.
5. Vapor Retarder Required: **No**.
6. Finish: **None**.

3.16 EQUIPMENT 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.

3.17 EXTERIOR TANK AND VESSEL INSULATION APPLICATION

A. Blankets, Board, and Block Applications for Tanks and Vessels: Secure 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 tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to the equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesive-attached or self-adhesive anchor pins and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. On tank and vessel, 3 inches maximum from insulation end joints, and 16 inches o.c. in both directions.
   c. Do not overcompress insulation during installation.
   d. Cut and miter insulation segments to fit curved sides and dome heads of tanks and vessels.
5. Impale insulation over anchor pins and attach speed washers.
6. 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
7. Secure each layer of insulation with stainless-steel bands.
8. Stagger joints between insulation layers at least 3 inches (75 mm).
9. Apply insulation in removable segments on equipment access doors and other elements that require frequent removal for service.
10. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
11. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

B. Flexible Elastomeric Thermal Insulation Applications for Tanks and Vessels: Apply insulation over entire surface of tanks and vessels according to the manufacturer's written instructions.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.18 EXTERIOR TANK AND VESSEL INSULATION APPLICATION SCHEDULE

A. Equipment: Chilled-water air separators and compression tanks.

1. Operating Temperature: 35 to 75 deg F .
2. Insulation Material: **Cellular glass.**
3. Insulation Thickness: 2” thick
4. Field-Applied Jacket: No.
5. Vapor Retarder Required: No.
6. Finish: Painted with UV protective coating.

END OF SECTION 23 07 01

23 09 00 Instrumentation and Control for HVAC

The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support BACnet communication protocol standards and integrate a wide variety of third-party BACnet devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks. The system must currently have the Authority to Operate (ATO) on the Keesler AFB CE VLAN. Acceptable Manufacturers: Johnson Controls, Inc., Metasys and Siemens Apogee.

A. General Requirements
   1. Damper and valve actuators shall be electronic as specified in the System Description section.
   2. The manufacturer shall be ISO 9001 certified.

B. Electronic Damper Actuators
   1. Spring Return Actuators:
      a. Manufactured, brand labeled or distributed by Johnson Controls, Inc. Siemens or approved equivalent.
      b. Regulatory Agency Listing: cULus ,CSA C22.2 No. 24-93, and CE marked
      c. Direct-Coupled Design: Requires no crankarm or linkage for mounting to a shaft.
      d. Coupling: toothed V-bolt clamp and nuts with toothed cradle.
      e. Reversible Mounting: Provides either clockwise or counterclockwise operation.
      f. Power Failure Operation: Mechanical spring return system drives load to the home position. Other forms of internal energy storage for power failure operation are not acceptable.
      g. Motor Technology:
         i. Modulating Types: Microprocessor-controlled Brushless DC motor
         ii. On/Off Types: DC brush motor.
      h. Overload Protection: Electronic stall detection protects from overload at all angles of rotation without the use of end switches.
      i. Enclosure Ratings:
         i. NEMA type 2 / IP54 mounted in any orientation.
      j. Double-Insulated construction: Eliminate the need for electrical ground wires.
      k. Wiring: Integral cables with colored and numbered conductors.
      l. Sized for torque required to seal damper at load conditions
      m. Parallel Operation: Actuators shall be available that are capable of being mechanically or electrically paralleled.
      n. Proportional actuators shall be user configurable without the use of external computer software or programming tools. Calibration, input signal range selection, and control logic reversal shall be selectable with an external mode selection switch.
      o. Operating Temperature Range:
         i. 70 lb·in. Torque and Below: -40°F to 140°F
         ii. 71 lb·in. Torque and above: -40°F to 131°F
      p. Power Requirements:
         i. Modulating Types:
            ◊ 27 lb·in. Torque and Below: 5VA maximum
            ◊ 70 lb·in. to 19 lb·in.Torque: 8VA maximum
            ◊ 89 lb·in. to 71 lb·in.Torque: 10VA maximum

- ◊ 90 lb·in. to 177 lb·in.Torque: 16VA maximum
- ii. 2-Position Types:
  - ◊ 27 lb·in. Torque and Below: 5VA maximum
  - ◊ 70 lb·in. to 19 lb·in.Torque: 7VA maximum
  - ◊ 71 lb·in. to 177 lb·in.Torque: 25VA maximum

C. Non-Spring Return Actuators:
   a. Manufactured, brand labeled or distributed by Johnson Controls, Inc. or approved equivalent.
   b. Regulatory Agency: UL Listed ,CSA Certified, and CE marked
   c. Direct-Coupled Design: Requires no crankarm or linkage for mounting to a shaft.
   d. Coupling:
      i. Above 80 lb.·in.: toothed V-bolt clamp and nuts with toothed cradled
      ii. 80 lb.·in.and below: single cup-point set screw and toothed cradle.
   e. Overload Protection: Electronic stall detection or magnetic slip clutch protects from overload at all angles of rotation without the use of end switches.
   f. Minimum Enclosure Ratings:
      i. Types with covered wiring terminals: NEMA type 2 / IP42 mounted in any orientation.
      ii. Types without covered wiring terminals: NEMA type 1 / IP30 or IP40.
      iii. Types with integrated cables: NEMA 2 / IP42 mounted in any orientation.
   g. Sized for torque required to seal damper at load conditions
   h. Parallel Operation: Actuators shall be available that are capable of being mechanically or electrically paralleled.
   i. Proportional actuators shall be user configurable without the use of external computer software or programming tools.
   j. Operating Temperature Range: -4°F to 122°F except for VAV and similar indoor applications in which case 32°F to 122°F is acceptable.
   k. Power Requirements: 24 V with models available for both 24 VAC and 24 VDC operation, maximum
      i. Above 80 lb.·in.: 7.5 VA at 24 VAC
      ii. 80 lb.·in.and below: 3.5 VA at 24VAC
   l. The manufacturer shall provide 3-year limited warranty from the date of sale covering defects in material or workmanship.

23 09 13.23 Sensors and Transmitters

A. General Requirements
   1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors
   1. General Requirements:
      a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
      b. The temperature sensor shall be of the resistance type, and shall be a two-wire RTD type.

c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	**Accuracy**
Chilled Water	± .5°F.
Room Temp	± .5°F.
Duct Temperature	± .5°F.
All Others	± .75°F.

2. Room Temperature Sensors
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. Room sensors shall have the following options when specified:
      i. Setpoint warmer/cooler dial or reset slide switch providing a ±3 degree (adjustable) range.
      ii. A momentary override request push button for activation of after-hours operation.

3. Room Temperature Sensors with Integral Display
   a. Room sensors shall be constructed for either surface or wall box mounting.
   b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:
      i. Display room air temperatures.
      ii. Display and adjust room comfort setpoint.
      iii. Display and adjust fan operation status.
      iv. Timed override request push button with LED status for activation of after-hours operation.
      v. Display controller mode.
      vi. Password selectable adjustment of setpoint and override modes.

4. Thermo wells
   a. Thermowell manufacturer shall have models available in stainless steel, brass body, and copper bulb.
   b. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and sensor.
   c. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
   d. Thermo wells and sensors shall be mounted in a direct mount (no adapter) offering faster installation or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
   e. Thermo wells constructed of 316 stainless steel shall comply with Canadian Registration Number (CRN) pressure vessel rating.

5. Outside Air Sensors
   a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
   b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
   c. Temperature transmitters shall be of NEMA 3R (IP54) or NEMA 4 (IP65) construction and rated for ambient temperatures.
   d. The outdoor sensor can be easily mounted on a roof, pole or side of a building utilizing its already assembled mounting bracket.

e. Outside Relative Humidity sensors 0-100% full range of accurate measurement. Operating temperature -4 to 140F (-20 to 60C).
f. Outside temperature sensors operating temperature range is -40 to 140F, +/- .55F (+/- .3C).

6. Duct Mount Sensors
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
   b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
   c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

7. Averaging Sensors
   a. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
   b. For plenum applications, such as mixed air temperature measurements, a continuous averaging sensor or a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
   c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

8. Acceptable Manufacturers: Johnson Controls, Siemens or approved equal.

C. Humidity Sensors
1. The sensor shall be a solid-state type, relative humidity sensor of the Thin Film Capacitance or Bulk Polymer Design. The sensor element shall resist service contamination.
2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, 0-10 vdc, 0-100% linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R (IP54) or NEMA 4 (IP65) enclosure with sealtite fittings.
5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
7. Acceptable Manufacturers: Johnson Controls, Siemens and Vaisala.

D. CO2 Sensors
1. Where shown on the drawings, C02 sensors shall have the following features:
   a. 0-10VDC output
   b. Liquid Crystal Display
2. The C02 sensors shall have the ability to monitor and output the following variables as required by the systems sequence of operations:
   a. Zone carbon-dioxide
3. The C02 shall transmit the information back to the controller via 0-10VDC output signals.
   a. The C02 sensors shall provide a maximum output current of 25mA; Maximum output voltage of 12.5V.
   b. The C02 sensors shall be FCC compliant to CFR47 Part 15 subpart B Class A.
4. The C02 Sensors shall be available with
   a. CO2 response time (0-63%) of 1 minute
   b. Less than 0.083% of full scale/F˚ temperature dependence of CO2 output

c. Long term CO2 stability ±5% of full scale for 5 years
d. CO2 measurement accuracy of ±(40ppm + 2.0% of reading)
e. CO2 non-linearity of less than 1.0% of full scale

E. Differential Pressure Transmitters
1. General Air and Water Pressure Transmitter Requirements:
a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC output signal.
c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Low Differential Water Pressure Applications (0” - 20” w.c.)
a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 0 – 10 vdc output in response to variation of flow meter differential pressure or water pressure sensing points.
b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
i. .01-20” w.c. input differential pressure range.
ii. 0-10vdc output.
iii. Maintain accuracy up to 20 to 1 ratio turndown.
iv. Reference Accuracy: +0.2% of full span.
c. Acceptable Manufacturers: Setra, Veris and Mamac.

3. Medium to High Differential Water Pressure Applications (Over 21” w.c.)
a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
i. Differential pressure range 10” w.c. to 300 PSI.
ii. Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
c. Acceptable Manufacturers: Setra, Veris and Mamac.

4. Building Differential Air Pressure Applications (-1” to +1” w.c.)
a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 0-10 vdc output in response to variation of differential pressure or air pressure sensing points.
b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
i. -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
ii. 0-10 vdc output.
iii. Maintain accuracy up to 20 to 1 ratio turndown.
iv. Reference Accuracy: +0.2% of full span.
c. Acceptable Manufacturers: Johnson Controls, Siemens, Veris and Setra

5. Low Differential Air Pressure Applications (0" to 2.5" w.c.)
   a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 0-10 vdc output in response to variation of differential pressure or air pressure sensing points.
   b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
      i. (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
      ii. 0-10 VDC, output.
      iii. Maintain accuracy up to 20 to 1 ratio turndown.
      iv. Reference Accuracy: +0.25%, or 0.5% of full span.
   c. Acceptable Manufacturers: Johnson Controls, Siemens, Setra and Veris.

6. Medium Differential Air Pressure Applications (5" to 21" w.c.)
   a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
      i. Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
      ii. Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
      iii. Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).
   b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
   c. Acceptable manufacturers: Johnson Controls Siemens, Setra and Veris.
   d.

F. Flow Monitoring

1. Air Flow Monitoring
   a. Fan Inlet Air Flow Measuring Stations
      i. At the inlet of each fan and near the exit of the inlet sound trap, airflow sensors shall be provided that shall continuously monitor the fan air volumes or velocity pressure.
      ii. Each sensor shall be surface mount type. Unit shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location through two or four sensing circuits. If a static pressure manifold is used, it shall incorporate dual offset static tips on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching air stream.
      iii. Devices creating fan performance degradation, resulting in additional energy consumption, caused from pressure drop associated with probes or mounting apparatus in the center of the fan inlet are not allowed. The device shall not induce a significant pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Sensor circuit casings shall be constructed of U.L. 94 flame rated, high impact ABS and include a stainless steel thermistor cap that maintains the precise calibrated flow over the heated and ambient measurement points. Each sensor circuit shall consist of two ceramic base, glass encapsulated, thermistors for measuring ambient temperature and velocity. Circuit shall be designed for operation in a wide range of environments, including high humidity (non-condensing) and rapid thermal cycling.
      iv. Acceptable manufacturers are: Ebtron
   b. Single Probe Air Flow Measuring Sensor

i. The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a thermal dispersion and utilize one temperature sensor and a heated thermistor. The sensor pair shall measure the air temperature and airflow velocity.

c. Duct Air Flow Measuring Stations
   i. Furnish and install, at locations shown on plans or as in accordance with schedules, an equalized air measuring probe system piped to a high performance pressure transducer or an electronic type airflow temperature measuring station.
   ii. Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.
   iii. Assembly shall be AMCA tested and capable of measuring a range from 70 to 5,000 FPM (22 to 1524 MPM).
   iv. Equalized air measuring assembly shall measure to ±3% average and consist of 6063T5 extruded aluminum step sensing blade(s) with anodized finish, plenum-rated polyethylene pressure tubing, brass barbed fittings, mounting hardware and a glass-on-silicone capacitance sensor pressure transducer capable of measuring up to five field-selectable pressure ranges up to 2.5 in. w.c.
   v. The transducer shall be accurate to ±0.5%, or 0.25% of full scale and be contained in a National Electrical Manufacturer's Association (NEMA) 4 (IP-65) enclosure. Transducer shall be factory mounted and piped to high and low pressure ports through fittings made of brass.
   vi. All sensor tubing shall terminate in solid brass barbed fittings.
   vii. Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.
   viii. Air straightener shall be provided for sizes over 17 square feet (1.6 sq meter).
   ix. Airflow measuring station assemblies shall be fabricated of galvanized steel or aluminum casing of appropriate thickness for slip fits or with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 5000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
   x. Equalized air measuring probe assemblies shall be, in all respects, equivalent to Ebtron Gold Series airflow measuring systems.
   xi. Electronic air measuring station shall be capable of monitoring and reporting the airflow and temperature at each measuring location through one or more measuring probes containing multiple sensor points and a control transmitter that outputs a 0 – 10 VDC OR 4-20 mA linear signal.
   xii. Probe(s) shall be constructed of an airfoil shaped aluminum extrusion containing the sensor circuit(s).
   xiii. Each sensor circuit shall consist of coated thermistors, for temperature and velocity, mounted to a Printed Circuit Board (PCB).
   xiv. Probe multiplexer circuit(s) shall include a microprocessor that collects data from each PCB and digitally communicates the average airflow and temperature of each probe to a microprocessor based control transmitter.
   xv. Multiplexer board shall be encased to prevent moisture damage.
   xvi. Shielded CAT5e communications cable shall be Underwriters Laboratories Inc.® (UL) plenum-rated with RJ45 terminal connectors. Dust boot covers and gold-plated contacts shall link probes to electronic controller.

xvii. Control transmitter shall be capable of processing independent sensing points and shall operate on a fused 24 VAC supply.
Control transmitter shall feature an alphanumeric LCD screen, digital offset/gain adjustment, continuous performing sensor/transmitter diagnostics, and a visual alarm to detect malfunctions.
xviii. All electronic components of the assembly shall be Restriction of Hazardous Substances (RoHS) Directive compliant.
xix. Equal to Ebtron Gold Series
xx. Installation Considerations
- ◊ The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .04" w.c. at 1000 feet per minute, or .11" w.c. at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 3-5% as determined by AMCA.
- ◊ Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be 1.5 inches to facilitate matching connecting ductwork.
- ◊ Where control dampers are shown as part of the airflow measuring station, parallel blade precision controlled volume dampers integral to the station and complete with actuator, and linkage shall be provided.
- ◊ Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

xxi. All air measuring devices shall be tested according to AMCA Standard 610
xxii. Acceptable manufacturers: Ebtron

d. Static Pressure Traverse Probe
   i. Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
   ii. Acceptable manufacturers: Cleveland Controls or equivalent
e. Shielded Static Air Probe
   i. A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.
f. Water Flow Monitoring
   i. Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.
   ii. Acceptable manufacturers: Onicon or approved equal

G. Power Monitoring Devices

1. Current Measurement (Amps)
   a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
   b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.
      i. Operating frequency – 50 - 400 Hz.
      ii. Insulation – 0.6 Kv class 10Kv BIL.
      iii. UL recognized.
      iv. Five amp secondary.
      v. Select current ration as appropriate for application.
      vi. Acceptable manufacturers: Setra

c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:
   i. 6X input over amp rating for AC inrushes of up to 120 amps.
   ii. Manufactured to UL 1244.
   iii. Accuracy: +.5%, Ripple +1%.
   iv. Minimum load resistance 30kOhm.
   v. Input 0-20 Amps.
   vi. Output 4-20 mA.
   vii. Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).
   viii. Acceptable manufacturers: Setra, Veris

H. Status and Safety Switches

1. General Requirements
   a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches
   a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
   b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
   c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
   d. Acceptable manufacturers: Johnson Controls, Siemens

3. Air Filter Status Switches
   a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
   b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
   c. Provide appropriate scale range and differential adjustment for intended service.
   d. Acceptable manufacturers: Johnson Controls, Cleveland Controls

4. Air Flow Switches
   a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
   b. Acceptable manufacturers: Johnson Controls, Cleveland Controls, Siemens

5. Air Pressure Safety Switches
   a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
   b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
   c. Acceptable manufacturers: Johnson Controls, Siemens, Cleveland Controls

6. Water Flow Switches
   a. Water flow switches shall be equal to the Johnson Controls P74.

7. Low Temperature Limit Switches
   a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
d. The low temperature limit switch shall be equal to Johnson Controls A70 or equal.

I. Control Relays

1. Control Pilot Relays
   a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
   b. Mounting Bases shall be snap-mount.
   c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
   d. Contacts shall be rated for 10 amps at 120VAC.
   e. Relays shall have an integral indicator light and check button.
   f. Acceptable manufacturers: IDEC

2. Lighting Control Relays
   a. Lighting control relays shall be latching with integral status contacts.
   b. Contacts shall be rated for 20 amps at 277 VAC.
   c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.
   d. Lighting control relays shall be controlled by:
      i. Pulsed Tri-state Output – Preferred method.
      ii. Pulsed Paired Binary Outputs.
      iii. A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the “dry-contact” type.
   e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

J. Electronic Signal Isolation Transducers

1. A signal isolation transducer shall be provided whenever an analog output signal from the BMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.
2. The signal isolation transducer shall provide ground plane isolation between systems.
3. Signals shall provide optical isolation between systems.
4. Acceptable manufacturers: Advanced Control Technologies or equal

K. Electronic/Pneumatic Transducers

1. Electronic to Pneumatic transducers shall provide:
   a. Output: 3-15 PSIG.
   b. Input: 4-20 mA or 0-10 VDC.
   c. Manual output adjustment.
   d. Pressure gauge.
   e. External replaceable supply air filter.
   f. Acceptable manufacturers: Johnson Controls, Siemens, Mamac

L. Thermostats

1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

23 09 13.33 Control Valves

A. Ball Valves, 1/2 through 2 in.:

1. Ball Valves shall have forged brass bodies.
2. Valves shall have available either Chrome Plated Brass Balls or 300 Series Stainless Steel Balls in all sizes.
3. Valves shall have available either Nickel Plated Brass Stems or 300 Series Stainless Steel Stems with a blow-out proof stem design in all sizes.
4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow Characterization Disk shall be Polyphthalamide Resin and rated for 50 psid maximum differential pressure and shall be inserted against the casting of the valve.
7. All ball valves with internal pipe thread end connections shall be rated to 580 psi maximum static pressure at 203°F (95°C) fluid temperature.
8. All ball valves with sweat end connections or press end connection shall be rated to 300 psig maximum static pressure at 203°F (95°C) fluid temperature
9. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
10. Ball Valves with stainless steel balls and stems shall be rated for use with 15 psig saturated steam.
11. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
12. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
13. Valves shall be maintenance free
14. Valves shall be provided with a3 year warranty.
15. Valves shall be rated for 200 psid closeoff pressure.
16. Valve actuators shall be UL-recognized or CSA-certified.
17. Valves shall be Johnson Controls VG1000 Series ball valves, Siemens or approved equal.

B. Ball Valves, 2-1/2 through 4 in. Flanged:

1. Ball Valves shall have forged brass bodies with ASME Class 150 ductile iron flanges.
2. Valves shall have 300 Series Stainless Steel Balls.
3. Valves shall have 300 Series Stainless Steel Stems with a blow-out proof stem design.
4. Valves shall have Graphite reinforced Polytetrafluoroethylene (PTFE) seats with Ethylene Propylene Diene Monomer (EPDM) O-ring backing.
5. Stem seals shall be double EPDM O-rings.
6. Flow Characterization Disk shall be manufactured from Amodel AS-1145HS Polyphthalamide Resin and rated for 50 psid maximum differential pressure.
7. Flow Characteristics shall be equal percentage on the control port. Bypass port on three-way valves shall have linear flow characteristics.
8. Valves shall have a maximum leakage specification of 0.01% of maximum flow for the control port, ANSI/FCI 70-2, Class 4 and 1% of maximum flow, bypass port.
9. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and rated for use with 25 psig saturated steam.
10. Two-Way Valves shall be rated for 100 psid closeoff pressure and Three-Way Valves shall be rated for 50 psid closeoff pressure.

11. Valves shall be maintenance free.
12. Valves shall be provided with a 3 year warranty.
13. Valve actuators shall be UL-recognized or CSA-certified.
14. Valves shall be Johnson Controls VG1000 Series ball valves, Siemens or approved equal.

C. Butterfly Valves, 2 through 20 in. resilient seat ASME Class 125/150 Flanged:

1. Butterfly Valves shall have cast iron bodies meetings ASTM A126 Class B requirements and meet ASME class 125/150 flange requirements and shall be fully lugged.
2. Butterfly Valves seat shall be Ethylene Propylene Diene Monomer (EPDM).
3. Butterfly Valve disk shall be Ductile Iron with Nylon 11 coating.
4. Butterfly Valve stems shall be Stainless Steel.
5. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
6. All valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
7. Valves shall be maintenance free.
8. Valve shall be provided with a 3 year warranty.
9. Valve electric actuators shall be UL-recognized or CSA-certified.
10. Valves shall be Johnson Controls VF Series butterfly valves, Siemens or approved equal.

D. Butterfly Valves, High Performance 2-1/2 through 16 in.

1. Butterfly Valves shall have bodies manufactured from Carbon Steel, ASTM A216 GR WCB/A516 GR 70 and shall be fully lugged per ASME Class 150 or ASME Class 300.
2. Butterfly Valves seat assembly shall be RPTFE (reinforced polytetrafluoroethylene) and the seat retainer shall be Carbon Steel, ASTM A516 GR 70
3. Butterfly Valve disk shall be Stainless Steel, ASTM A 351 GR CF8M
4. Butterfly Valve stems shall be 17-4 PH Stainless Steel, ASTM A564-Type 630
5. Butterfly Valve Stem Seals shall be One Carbon Fiber Ring and Three TFE Rings
6. Flow Characteristics shall be equal percentage up to 70° of disk rotation.
7. All valves shall be rated for service with hot water, chilled water, 50% glycol solutions and 50 psig saturated steam in modulating service or 150 psig saturated steam in two position service.
8. Butterfly Valves shall meet the performance requirements of ASME Class 150 or Class 300.
9. Valves shall be maintenance free.
10. Valves shall be provided with a 3 year warranty.
11. Valve electric actuators shall be UL-recognized or CSA-certified.
12. Valves shall be Johnson Controls VF Series butterfly valves, Siemens or approved equal.

E. Globe Valves, Brass, 1/2 through 2 in.

1. Valves shall have bodies manufactured from a RoHS compliant brass.
2. Valves shall meet the pressure and temperature requirements of ANSI B16.15, Class 250
3. Valve stems shall be a 300 Series Stainless Steel.
4. Valves with brass plug and seat shall have stem seals with Self-Adjusting Ethylene Propylene Rubber (EPR) Ring Pack U-Cups
5. Valves with Stainless Steel plug and seat shall valve stem seals with Spring Loaded Polytetrafluoroethylene (PTFE) and Elastomer V-Rings

6. Valves with brass trim shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2, Class 4 and valves with stainless steel trim shall have a maximum leakage of 0.05% of maximum flow
7. Flow Characteristics shall be equal percentage for two-way valves and linear for three-way valves.
8. Valves shall be serviceable without being removed from the pipe.
9. Valves shall be provided with a 3 year warranty.
10. Valve electric actuators shall be UL-recognized or CSA-certified.
11. Valves shall be Johnson Controls VG7000 Series globe valves, Siemens or approved equal.

F. Globe Valves, Cast Iron, 2-1/2 through 6 in.

1. Valves shall have bodies manufactured from cast iron.
2. Valves shall meet the pressure and temperature requirements of ANSI B16.1, Class 125
3. Valve stems shall be a 316 Series Stainless Steel.
4. Valves shall have stem seals with Ethylene Propylene Terpolymer (EPT) Ring Pack U-Cups
5. Valves shall have a maximum leakage specification of 0.1% of maximum flow per ANSI/FCI 70-2, Class 3
6. Flow Characteristics shall be equal modified linear.
7. Valves shall be serviceable without being removed from the pipe.
8. Valves shall be provided with a 3 year warranty.
9. Valve electric actuators shall be UL-recognized or CSA-certified.
10. Valves shall be Johnson Controls VG2000 Series globe valves, Siemens or approved equal.

G. Electric Zone Valves, 1/2 through 1-1/4 in.

1. Valves shall have bodies manufactured from Forged Brass.
2. Valves stems shall be brass (Hard Chrome Plated)
3. Valve Actuator shall be UL, cUL listed or CSA certified.
4. Valves shall be rated for service with hot water, chilled water and 50% glycol solutions.
5. Two Position valves shall have models available rated for use with 15 psig saturated steam.
6. Valve Actuator shall be replaceable without removing valve from the pipe.
7. Modulating Valves flow characteristics shall be equal percentage
8. Valves shall be provided with a 2 year warranty.
9. Valve actuators shall be UL-recognized or CSA-certified.
10. Valves shall be Johnson Controls J Series electric zone valves, Siemens or approved equal.

H. Pressure Independent Valves, 1/2 through 2 in.

1. Valves bodies shall be manufactured from forged brass and shall be nickel plated
2. Valves shall have a stem and ball manufactured from chrome plated brass
3. Valve seat shall be fiberglass reinforced with Teflon®
4. Characterizing disk shall be brass for 1/2 and 3/4 in. valves, and Tefzel® for sizes 1 through 2 in. valves
5. Valves shall pressure ratings of 600 psi for 1/2, 3/4 and 1 in. size valves, and pressure rating of 400 psi for 1-1/4, 1-1/2 and 2 in. size valves
6. Closeoff Pressure rating shall be 200 psid

7. Valves shall have a maximum leakage specification of 0.01% of maximum flow per ANSI/FCI 70-2,
   Class 4 with a 50 psid differential pressure applied.
8. Valves shall be maintenance free.
9. Valves shall be provided with a 5 year warranty.
10. Valve actuators shall be UL-recognized or CSA-certified.
11. Valves shall be Johnson Controls P1000 Series pressure independent valves, Siemens or approved equal.

23 09 13.43 Control Dampers

A. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.

B. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

C. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

D. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

E. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g.

   1. Acceptable manufacturers are Johnson Controls , Siemens and Ruskin or approved equal.

F. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.

   1. Acceptable manufacturers are: Johnson Controls, Ruskin and Siemens .

G. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

23 09 23 Direct-Digital Control System for HVAC

Part 1 – General

Table of Contents

1.A Related Documents

1. All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.
2. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.
3. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.
4. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.B Definitions

1. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

2. Binary: A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level.
3. Building Management System (BMS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Contractor and to be interfaced to the associated work of other related trades.
4. BMS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMS work.
5. Control Sequence: A BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
6. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
7. BMS Network: The total digital on-line real-time interconnected configuration of BMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
8. Node: A digitally programmable entity existing on the BMS network.
9. BMS Integration: The complete functional and operational interconnection and interfacing of all BMS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.
10. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
11. PC: Personal Computer from a recognized major manufacturer
12. Furnish: The term “Furnish” and its derivatives when used in this Division shall mean supply at the BMS Contractor’s cost to the designated third party trade contractor for installation. BMS Contractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.
13. Wiring: The term “Wiring” and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.
14. Install: The term “Install” and its derivatives when used in this Division shall mean receive at the jobsite and mount.
15. Protocol: The term “protocol” and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMS network nodes.
16. Software: The term “software” and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMS industry for real-time, on-line, integrated BMS configurations.
17. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
18. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.

19. The following abbreviations and acronyms may be used in describing the work of this Division:

ADC	-	Analog to Digital Converter
AHJ	-	Authority Having Jurisdiction
AI	-	Analog Input
AN	-	Application Node
ANSI	-	American National Standards Institute
AO	-	Analog Output
ASCII	-	American Standard Code for Information Interchange
ASHRAE		American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG	-	American Wire Gauge
BTL	-	BACnet Testing Laboratories
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
DAC	-	Digital to Analog Converter
DDC	-	Direct Digital Control
DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electronically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
GUI	-	Graphical User Interface
HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/Output
IT	-	Information Technology
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MCC	-	Motor Control Center
NC	-	Normally Closed
NIC	-	Not In Contract
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume

VDC	-	Volts, Direct Current
WAN	-	Wide Area Network

1.C BMS Description

1. The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
2. Any and all components of the BMS that are connected via field bus or IP network, including the network controllers, field controllers, application specific controllers, server and user interface software, system and controller programming tools and software applications shall be designed, engineered, and tested to work together as a complete building management system, and shall be manufactured by the same BMS manufacturer. Systems that use or require network controllers, field controllers, application specific controllers, server and user interface software, programming tools and software from more than one BMS manufacturer shall not be accepted.
3. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.
4. Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft SQL Server Express or Microsoft SQL Server as dictated elsewhere in this specification.
5. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
6. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.
7. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
8. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
9. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:
    a. Operator information, alarm management and control functions.
    b. Enterprise-level information and control access.
    c. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
    d. Diagnostic monitoring and reporting of BMS functions.
    e. Offsite monitoring and management access.
    f. Energy management

g. Standard applications for terminal HVAC systems.

1.D Quality Assurance

1. General
   i. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.
   ii. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.
   iii. The Building Management System (BMS) installer shall be a BMS manufacturer-owned branch office, or an independent controls contractor who is factory trained and authorized by the BMS manufacturer to sell, service and support the Building Management System specified herein.
   iv. Independent controls contractors who are authorized by the BMS manufacturer must provide a letter written and signed by a company officer of the specific BMS manufacturer. This document must be dated within the 30 days prior to bid submittal and must state that they are currently a “direct authorized representative” in good standing for the BMS manufacturer for the building management system products described and listed in this specification, that they have “direct purchasing access” to all of the BMS manufacturer’s controllers, servers, software and components and technical support, and that they will continue to be an Authorized representative with this access for the duration of the installation and warranty phases of project.
   v. If an independent controls contractor is to be considered via addendum, the contractor must provide a letter written by a company officer of the specific BMS manufacturer with the following verbiage; “should this contractor fail to provide a complete and operational system (as judged by the owner/engineer), the Manufacturer will complete the project to the Engineer’s satisfaction at no additional cost to the Owner”. This letter must be dated within 30 days prior to bid submittal and provided to the engineer along with the other supporting documentation at the time of request for equivalence.
   vi. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis. The BMS Contractor shall have at this facility at least eight (8) factory trained, directly employed and full time technical staff, spare parts inventory, and all necessary test and diagnostic equipment.
   vii. As evidence and assurance of the contractor’s ability to support the Owner's system with service and parts, the contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
   viii. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer’s latest standard of design at the time of bid.
2. Workplace Safety and Hazardous Materials
   a. Provide a safety program in compliance with the Contract Documents.
   b. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
   c. The Contractor and its employees and subtrades shall comply with federal, state and local safety regulations.
   d. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA rules that have jurisdiction for at least each topic listed in the Safety Certification Manual.

e. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
f. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
g. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
h. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.
i. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

3. Quality Management Program
   a. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manger shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Manager shall:
      ◊ Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
      ◊ Manage the financial aspects of the BMS Contract.
      ◊ Coordinate as necessary with other trades.
      ◊ Be responsible for the work and actions of the BMS workforce on site.

1.E References

1. All work shall conform to the following Codes and Standards, as applicable:
   a. National Fire Protection Association (NFPA) Standards.
   b. National Electric Code (NEC) and applicable local Electric Code.
   c. Underwriters Laboratories (UL) listing and labels.
   d. UL 268 Smoke Detectors.
   e. UL 916 Energy Management
   f. NFPA 70 - National Electrical Code.
   g. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
   h. NFPA 92A and 92B Smoke Purge/Control Equipment.
   i. Factory Mutual (FM).
   j. American National Standards Institute (ANSI).
   k. National Electric Manufacturer's Association (NEMA).
   l. American Society of Mechanical Engineers (ASME).
   m. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE); ASHRAE 62 IAQ.
   n. Air Movement and Control Association (AMCA).
   o. Institute of Electrical and Electronic Engineers (IEEE).
   p. American Standard Code for Information Interchange (ASCII).
   q. Electronics Industries Association (EIA).
   r. Occupational Safety and Health Administration (OSHA).

s. American Society for Testing and Materials (ASTM).
t. ANSI/ASHRAE Standard 195-2008 (BACnet)

2. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
3. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

*1: BMS low voltage and communications wiring BMS Ethernet communications cable: furnished and installed by BMS Contractor.

*2: VAV box controller factory install would normally be by Division 23 Mechanical who furnishes the VAV boxes; could be by BMS for field installation where applicable

*3: Electric Baseboard Heating Controls – for line voltage stand-alone controls: furnished by Division 23 Mechanical Contractor who furnishes the baseboard units; line voltage controls installed and connected by Division 26 Electrical Contractor. Alternate: controls to be furnished and installed by BMS Contractors for projects requiring Baseboard Heating controls to be integrated into BMS. Refer to Section 230993 SEQUENCE OF OPERATIONS

*4: Smoke Detector also wired to shut down AHU/HVAC by BMS Contractor; Division 26 for projects NYC

*5: Fire/Smoke Dampers: BMS Contractor to provide and ensure OPEN/CLOSE control of Fire/Smoke dampers is coordinated between BMS HVAC systems sequences, controls and overrides, and the Fire Alarm system control status priorities and overrides

*6: Cabinet/Unit Heater Controls – for line voltage stand-alone controls: furnished by Division 23 Mechanical Contractor who furnishes the Cabinet/Unit Heaters; line voltage stand-alone controls installed and connected by Division 26 Electrical Contractor. Alternate: controls to be furnished and installed by BMS Contractors for projects requiring Cabinet/Unit Heater controls to be integrated into BMS. Refer to Section 230993 SEQUENCE OF OPERATIONS

1.F -Submittals

1. Shop Drawings, Product Data, and Samples
   a. The BMS contractor shall submit a list of all shop drawings with submittals dates within 14 days of contract award.
   b. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
   c. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.
   d. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
   e. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
   f. The BMS Contractor shall correct any errors or omissions noted in the first review.
   g. At a minimum, submit the following:
      ◊ BMS network architecture diagrams including all nodes and interconnections.
      ◊ Systems schematics, sequences, and flow diagrams.
      ◊ Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.

- ◊ Samples of Graphic Display screen types and associated menus.
- ◊ Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
- ◊ Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
- ◊ Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
- ◊ Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
- ◊ Details of all BMS interfaces and connections to the work of other trades.
- ◊ Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.G Record Documentation

1. Operation and Maintenance Manuals
   a. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:
      - ◊ Table of contents.
      - ◊ As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
      - ◊ Manufacturer’s product data sheets or catalog pages for all products including software.
      - ◊ System Operator’s manuals.
      - ◊ Archive copy of all site-specific databases and sequences.
      - ◊ BMS network diagrams.
      - ◊ Interfaces to all third-party products and work by other trades.
   b. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.
2. On-Line documentation: After completion of all tests and adjustments the contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server

1.H Warranty

1. Standard Material and Labor Warranty:
   a. Provide a one-year labor and 3 year material warranty on the BMS.
   b. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

      Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor’s normal business hours

Part 2 – Products

2.A General Description

1. The Building Management System shall consist of the following:
   a. Supervisory Controller
   b. Field Equipment Controller(s)
   c. Input/Output Module(s)
   d. Local Display Device(s)
   e. Distributed User Interface(s)
   f. Network processing, data storage and communications equipment
   g. Other components required for a complete and working BMS
2. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
   a. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
   b. The System shall maintain all settings and overrides through a system reboot.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
   a. The System shall comply with the following NFPA Codes and Standards as applicable:
      i. NFPA 70 National Electrical Code
      ii. NFPA 72 National Fire Alarm Code
      iii. NFPA 101 Life Safety Code
      iv. NFPA 90A Standard for the Installation of Air-Conditioning and Ventilation Systems

2.B BMS Architecture

1. Automation Network
   a. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.
   b. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
   c. All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
   d. Supervisory controllers shall reside on the automation network.
   e. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
2. Control Network
   a. The supervisory controllers shall provide supervisory control over the control network and shall support the following communication protocols:

i. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9
   (a) Controllers shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
   (b) The controllers shall be tested and certified as a BACnet Building Controller (B-BC).

b. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 38400 baud.

c. DDC Controllers shall reside on the control network.

d. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

e. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

3. Integration
   a. Hardwired
      i. Analog and digital signal values shall be passed from one system to another via hardwired connections.
      ii. There will be one separate physical point on each system for each point to be integrated between the systems.
   b. BACnet Protocol Integration - BACnet
      i. The neutral protocol used between systems will be BACnet over Ethernet or BACnet MSTP and comply with the ASHRAE BACnet standard 135-2008.
      ii. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
      iii. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

1. Site Management User Interface Application Components
   a. Operator Interface
      i. An integrated browser based client application shall be used as the user operator interface program.
      ii. The System shall employ an event-driven rather than a device polling methodology to dynamically capture and present new data to the user.
      iii. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
      iv. The user interface software shall provide help menus and instructions for each operation and/or application.
      v. The system shall support customization of the UI configuration and a home page display for each operator.
      vi. The system shall support user preferences in the following screen presentations:
         ◊ Alarm
         ◊ Trend
         ◊ Display
         ◊ Applications
      vii. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, run-times, point statistics, schedules, and so forth.
      viii. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

- ◊ User access for selective information retrieval and control command execution
- ◊ Monitoring and reporting
- ◊ Alarm, non-normal, and return to normal condition annunciation
- ◊ Selective operator override and other control actions
- ◊ Information archiving, manipulation, formatting, display and reporting
- ◊ BMS internal performance supervision and diagnostics
- ◊ On-line access to user HELP menus
- ◊ On-line access to current BMS as-built records and documentation
- ◊ Means for the controlled re-programming, re-configuration of BMS operation and for the manipulation of BMS database information in compliance with the prevailing codes, approvals and regulations for individual BMS applications

ix. The system shall support a list of application programs configured by the users that are called up by the following means:
- ◊ The Tools Menu
- ◊ Hyperlinks within the graphics displays
- ◊ Key sequences

x. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

b. Navigation Trees

i. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.

ii. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.

b. Alarms

i. Alarms shall be routed directly from the supervisory controller to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
- ◊ Log date and time of alarm occurrence.
- ◊ Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
- ◊ Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
- ◊ Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
- ◊ Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
- ◊ Configuration of which controller offline alarms are seen by each user
- ◊ Any attribute of any object in the system may be designated to report an alarm.

ii. The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.

iii. The BMS shall allow a minimum of 4 categories of alarm sounds customizable through user defined wav.files.

iv. The BMS shall annunciate application alarms at minimum, as required by Part 3.

c. Reports and Summaries
   i. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
      ◊ All points in the BMS
      ◊ All points in each BMS application
      ◊ All points in a specific controller
      ◊ All points in a user-defined group of points
      ◊ All points currently in alarm
      ◊ All points locked out
      ◊ All user defined and adjustable variables, schedules, interlocks and the like.
   ii. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
   iii. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
   iv. Provide the capability to view, command and modify large quantities of similar data in tailored summaries created online without the use of a secondary application like a spreadsheet. Summary definition shall allow up to seven user defined columns describing attributes to be displayed including custom column labels. Up to 100 rows per summary shall be supported. Summary viewing shall be available over the network using a standard Web browser.
   v. Reports shall be selectable by date, time, area and device. Each report shall include a color visual summary of essential energy information.

d. Schedules
   i. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
      ◊ Weekly schedules
      ◊ Exception Schedules
      ◊ Monthly calendars
   ii. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
   iii. It shall be possible to define one or more exception schedules for each schedule including references to calendars
   iv. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
   v. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
   vi. Schedules and Calendars shall comply with ASHRAE SP135/2008 BACnet Standard.
   vii. The Calendar object supports an option to add a reference to another Calendar Object that is designated to be the master for the facility. Any Supervisory and BAC calendars can be configured to reference a single master Global Calendar. Changes to the master global calendar are automatically synced with all calendars that are referenced.
   viii. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

ix. Software shall be provided to configure and implement optimal start and stop programming based on existing indoor and outdoor environmental conditions as well as equipment operating history
x. The system Solar Clock shall support the scheduling and energy management functions. The Solar Clock will calculate the sunrise, sunset, and sun angle values for a specified latitude and longitude. A time offset can also be specified. An example would be to use the Solar Clock object as a master to an interlock to turn lights on 30 minutes after sunset and off 30 minutes before sunrise.

e. Security/Passwords
   i. Multiple-level passwords access protection shall be provided via roles and permissions. The feature will allow the system to base access on a user's job title or role and allow the user/manager access interface control, display, and database manipulation capabilities based on an assigned password.
   ii. Roles may be copied and altered to meet specific roles and permissions based on the particular policies.
   iii. Each user shall have the following: a user account name (with a maximum of 30 characters), a complex password or passphrase (with a min of 8 characters and a max of 50 characters), other user account policies (such as session timeout), timesheet access based on day of the week and time of day, and specific user view.
   iv. The system shall allow each user to change his or her password at will.
   v. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
   vi. A maximum of 150 categories may be used to determine or assign areas of responsibilities to each user account. A maximum of 13 (of the 150) named categories which are specifics such as "No Access, View, Advanced Review, Operate, Intervene, Diagnostic, Manage Item Events, Manage Every, and Configure Items".
   vii. A minimum of 100 unique passwords shall be supported.
   viii. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
   ix. Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.
   x. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.
   xi. The system shall have the ability to provide a Department of Defense (DoD) specific warning banner for applicable sites that warns the user they are accessing a restricted site.
   xii. After successful login to the Site Management Portal (SMP) the last time and date that user name was previously logged in is shown on the screen.
   xiii. Each login attempt is recorded in the system Audit Log with the option to record the IP address of the PC that made the login.
f. Screen Manager
   i. The system will allow a customized image on the login screen (i.e. organization name, logo).

ii. User View navigations can be displayed as either a set of tabs or a drop down list.
iii. Allows user preference for assigning of a background color for when an object is Out of Service which will enable the operator to quickly distinguish points that have been commanded to this state.
iv. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

g. Dynamic Color Graphics
i. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
ii. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
iii. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
◊ All graphics shall be fully scalable
◊ The graphics shall support a maintained aspect ratio.
◊ Multiple fonts shall be supported.
◊ Unique background shall be assignable on a per graphic basis.
◊ The color of all animations and values on displays shall indicate the status of the object attribute.
◊ Graphics that represent buildings or systems shall allow natural links and transitions between related detailed tabular views of data that complement the graphic.
iv. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment directly from the graphic.
v. Floor Plan graphics – The user interface shall provide graphic applications that summarize conditions on a floor. Floor plan graphics shall indicate thermal comfort using dynamic colors to represent zone temperature deviations from zone setpoint(s). Floor plan graphics shall display overall metrics for each zone in the floor.
vi. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.
vii. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
◊ The graphic editing tool shall provide a library of standard HVAC equipment, floor plan, lighting, security and network symbols.
◊ The graphic editing tool shall provide for the creation and positioning of library symbols by dragging from tool bars or drop-downs and positioning where required.
◊ The graphics editing tool shall permit the importing of AutoCAD drawings for use in the system.
◊ The graphic editing tool shall be able to add additional content to any graphic by importing images in the SVG, PNG or JPG file formats.

h. Historical trending and data collection

i. The Building Automation Server shall store trend and point history data for all analog and digital inputs and outputs, as follows:
◊ Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:
1. Defined time interval
2. Upon a change of value

1. Local Control Panels
   a. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
   b. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
   c. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
   d. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
   e. All wiring shall be neatly installed in plastic trays or tie-wrapped.
   f. A 120 volt convenience outlet, fused on/off power switch, and required transformers shall be provided in each enclosure.
   g. A 120 volt surge protection device shall be provided to protect all DDC controllers

2. Power Supplies
   a. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
   b. Input: 120 VAC +10%, 60Hz.
   c. Output: 24 VDC.
   d. Line Regulation: +0.05% for 10% line change.
   e. Load Regulation: +0.05% for 50% load change.
   f. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
   g. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
   h. A power disconnect switch shall be provided next to the power supply.

Part 3 – Performance/Execution

3.A BMS Specific Requirements

1. Graphic Displays
   a. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
   b. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.
2. Custom Reports:
   a. Provide custom reports as required for this project
3. Actuation / Control Type
   a. Primary Equipment
      i. Controls shall be provided by equipment manufacturer as specified herein.
      ii. All damper and valve actuation shall be electric.

b. Air Handling Equipment
   i. All air handlers shall be controlled with a HVAC-DDC Controller
   ii. All damper and valve actuation shall be electric.
c. Terminal Equipment:
   i. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.
   ii. All Terminal Units shall be controlled with HVAC-DDC Controller.

3.B Installation Practices

1. BMS Wiring
   a. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
   b. All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.
   c. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BMS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
   d. Class 2 Wiring
      i. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
      ii. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
   e. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
   f. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
2. BMS Line Voltage Power Source
   a. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
   b. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

3. BMS Raceway
   a. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2”.
   b. Wiremold is not acceptable.
   c. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
   d. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 6 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

4. Penetrations
   a. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
   b. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
   c. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
   d. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
5. BMS Identification Standards
   a. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
   b. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
6. BMS Panel Installation
   a. The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
   b. The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
7. Input Devices
   a. All Input devices shall be installed per the manufacturer recommendation
   b. Locate components of the BMS in accessible local control panels wherever possible.
8. HVAC Input Devices – General
   a. All Input devices shall be installed per the manufacturer recommendation
   b. Locate components of the BMS in accessible local control panels wherever possible.
   c. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
   d. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
   e. Outside Air Sensors
      i. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
      ii. Sensors shall be installed with a rain proof, perforated cover.
   f. Water Differential Pressure Sensors
      i. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
      ii. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
      iii. The transmitters shall be installed in an accessible location wherever possible.
   g. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
      i. Air bleed units, bypass valves and compression fittings shall be provided.
   h. Building Differential Air Pressure Applications (-1" to +1" w.c.):
      i. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
      ii. The interior tip shall be inconspicuous and located as shown on the drawings.
   i. Duct Temperature Sensors:
      i. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
      ii. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
      iii. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

iv. The sensor shall be mounted to suitable supports using factory approved element holders.

j. Space Sensors:
   i. Shall be mounted per ADA requirements.
   ii. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

k. Low Temperature Limit Switches:
   i. Install on the discharge side of the first water or steam coil in the air stream.
   ii. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
   iii. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

l. Air Differential Pressure Status Switches:
   i. Install with static pressure tips, tubing, fittings, and air filter.

m. Water Differential Pressure Status Switches:
   i. Install with shut off valves for isolation.

n. HVAC Output Devices

o. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

p. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

q. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

r. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

s. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.C Training

1. The BMS contractor shall provide the following training services:
   a. Eight hours of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.D Commissioning

1. Fully commission all aspects of the Building Management System work.
2. Acceptance Check Sheet
   a. Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.
   b. Submit the check sheet to the Engineer for approval
   c. The Engineer will use the check sheet as the basis for acceptance with the BMS Contractor.
3. VAV box performance verification and documentation:
   a. The BMS Contractor shall test each VAV box for operation and correct flow. At each

step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.

b. The BMS Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.

4. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

SECTION 23 31 00 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes rectangular and round, metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 2- to plus 10-inch wg.

B. Related Sections include the following:

1. Division 10 Section "Louvers and Vents" for intake and relief louvers and vents connected to ducts and installed in exterior walls.
2. Division 15 Section "Mechanical Insulation" for duct insulation.
3. Division 15 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Division 15 Section "Duct Accessories" for dampers, (duct-mounted access doors and panels) turning vanes, and flexible ducts.
5. Division 15 Section "Air Terminals" for constant-volume and reheat boxes.
6. Division 15 Section "Diffusers, Registers, and Grilles."
7. Division 15 Section "Testing, Adjusting, and Balancing" for air balancing and final adjusting of manual-volume dampers.

1.3 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F or W/m x K at the temperature differences specified. Values are expressed as Btu or W.

B. Example: Apparent Thermal Conductivity (k-Value): 0.26 or 0.037.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select and size air-moving and -distribution equipment and other components of air system. 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.

1.5 SUBMITTALS

A. Product Data: For duct liner and sealing materials.

B. Shop Drawings: Show details of the following:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating pressure classifications and sizes on plans.
3. Fittings.
4. Reinforcement and spacing.

5. Seam and joint construction.
6. Penetrations through fire-rated and other partitions.
7. Terminal unit, coil, and humidifier installations.
8. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and duct attachment.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
4. Coordination with ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," unless otherwise indicated.

B. Comply with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems," unless otherwise indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.

B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of

adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

1. Joint and Seam Tape: 2 inches wide; glass-fiber fabric reinforced.
2. Tape Sealing System: Woven-fiber tape impregnated with a gypsum mineral compound and a modified acrylic/silicone activator to react exothermically with tape to form a hard, durable, airtight seal.
3. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant, formulated with a minimum of 75 percent solids.
4. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.

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 round, threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rod or galvanized rods with threads painted after installation.
2. Straps and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for sheet steel width and thickness and for steel rod diameters.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized steel shapes and plates.

2.4 RECTANGULAR DUCT FABRICATION

A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply 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 classification.
2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

B. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:

1. Supply Ducts: 3-inch wg.
2. Return Ducts: 2-inch wg, negative pressure.
3. Exhaust Ducts: 2-inch wg, negative pressure.

C. 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 unbraced panel area, unless ducts are lined.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

A. Duct installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.

B. Construct and install each duct system for the specific duct pressure classification indicated.

1. Install ducts in lengths not less than 12 feet, unless interrupted by fittings.
2. Install ducts with fewest possible joints.

C. Install fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct.

E. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

I. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

J. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

K. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches (38 mm).

L. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, 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 "Firestopping."

3.2 SEAM AND JOINT SEALING

A. General: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Pressure Classification Less Than 2-Inch wg: Transverse joints.

C. Seal externally insulated ducts before insulation installation.

3.3 HANGING AND SUPPORTING

A. Install rigid round and rectangular metal duct with support systems indicated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

C. Support vertical ducts at a maximum interval of 16 feet and at each floor.

D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure load.

E. Install concrete inserts before placing concrete.

F. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3.4 CONNECTIONS

A. Connect equipment with flexible connectors according to Division 15 Section "Duct Accessories."

B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

3.5 FIELD QUALITY CONTROL

A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.

B. Conduct tests, in presence of Architect, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications 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.

C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

D. Maximum Allowable Leakage: Comply with requirements Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg.

E. Remake leaking joints and retest until leakage is less than maximum allowable.

F. Leakage Test: Perform tests according to SMACNA's "HVAC Air Duct Leakage Test Manual."

3.6 ADJUSTING

A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.

B. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed procedures.

3.7 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.

END OF SECTION 23 31 00

SECTION 23 33 00 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Manual-volume dampers.
3. Fire dampers.
4. Turning vanes.
5. Flexible ducts.
6. Flexible connectors.
7. Duct accessory hardware.

B. Related Sections include the following:

1. Division 10 Section "Louvers and Vents" for intake and relief louvers and vents connected to ducts and installed in exterior walls.
2. Division 15 Section "Air Terminals" for constant-volume and reheat boxes.
3. Division 15 Section "Diffusers, Registers, and Grilles."
4. Division 16 Section "Fire Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.
2. Manual-volume dampers.
3. Fire dampers.
4. Duct-mounted access doors and panels.
5. Flexible ducts.
6. Spin-In Fittings

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:

1. Special fittings and manual- and automatic-volume-damper installations.
2. Fire- and smoke-damper installations, including sleeves and duct-mounted access doors and panels.

C. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Comply with the following NFPA standards:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 (Z275) coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.

B. Extruded Aluminum: ASTM B 221, Alloy 6063, Temper T6.

C. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches .

2.2 BACKDRAFT DAMPERS

A. Description: Suitable for horizontal or vertical installations.

B. Frame: 0.052-inch- thick, galvanized, sheet steel, with welded corners and mounting flange.

C. Blades: 0.025-inch- thick, roll-formed aluminum.

D. Blade Seals: Neoprene.

1. Blade Axles: Galvanized steel.

E. Tie Bars and Brackets: Galvanized steel.

F. Return Spring: Adjustable tension.

2.3 MANUAL-VOLUME DAMPERS

A. General: 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 Classifications 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.

B. 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.

C. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

D. Jackshaft: 1-inch- diameter, galvanized steel pipe rotating within a 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 of a 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 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 FIRE DAMPERS

A. General: Labeled to UL 555.

B. Fire Rating: One and one-half hours.

C. Frame: SMACNA Type A with blades in airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

D. Mounting Sleeve: Factory installed galvanized, sheet steel.

1. Minimum Thickness: 0.052 inch or 0.138 inch thick as indicated, and 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.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. 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.

G. Horizontal Dampers: Include a blade lock and stainless-steel negator closure spring.

H. Fusible Link: Replaceable, 165 or 212 deg F rated as indicated.

2.5 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Manufactured Turning Vanes: Fabricate of 1-1/2-inch- wide, curved blades set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into side strips suitable for mounting in ducts.

C. Acoustic Turning Vanes: Fabricate of airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.6 DUCT-MOUNTED ACCESS DOORS AND PANELS

A. General: Fabricate doors and panels airtight and suitable for duct pressure class.

B. Frame: Galvanized, sheet steel, with bend-over tabs and foam gaskets.

C. Door: Double-wall, galvanized, sheet metal construction with insulation fill and thickness, and number of hinges and locks as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. Insulation: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.7 FLEXIBLE CONNECTORS

A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Standard Metal-Edged Connectors: Factory fabricated with a strip of fabric 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts.

C. Conventional, Indoor System Flexible Connector Fabric: Glass fabric double coated with polychloroprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp, and 360 lbf/inch (63 N/mm) in the filling.

2.8 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 1.

B. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch- thick, glass-fiber insulation around a continuous inner liner. Duct size indicated on drawings are measured as free area dimensions.

1. Reinforcement: Steel-wire helix encapsulated in inner liner.
2. Outer Jacket: Polyethylene film.
3. Inner Liner: Polyethylene film.

C. Pressure Rating: 6-inch wg positive, 1/2-inch wg (125 Pa) negative.

2.9 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 length to suit duct insulation thickness.

B. Splitter Damper Accessories: Zinc-plated damper blade bracket; 1/4-inch, zinc-plated operating rod; and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.

C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 to 18 inches to suit duct size.

D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct

Construction Standards--Metal and Flexible" for metal ducts.

B. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

C. Provide test holes at fan inlet and outlet and elsewhere as indicated.

D. Install fire dampers according to manufacturer's UL-approved written instructions.

1. Install fusible links in fire dampers.

E. Install duct access panels for access to both sides of duct coils. Install duct access panels downstream from volume dampers, fire dampers, turning vanes, and equipment.

1. Install duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining accessories and terminal units.
2. Install access panels on side of duct where adequate clearance is available.

3.2 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 23 33 00

SECTION 23 37 00 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 10 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 15 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
3. Division 15 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.3 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.

1.4 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.

1.5 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

2.1 MANUFACTURED UNITS

A. Diffusers, registers, and grilles are scheduled on Drawings.

2.2 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

3.1 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.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, original design, and referenced standards.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of the panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

3.4 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.

3.5 DIFFUSER SCHEDULE (Refer to Drawings)

END OF SECTION 15855

SECTION 23 40 00 - AIR FILTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

1.2 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Other manufacturers systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

B. Comply with NFPA 90A and NFPA 90B.

C. ASHRAE Compliance: Comply with provisions of ASHRAE 52.1 for method of testing and rating air-filter units.

D. Comply with ARI 850.

1.4 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. Provide one complete set of filters for each filter unit. If system includes prefilters, provide only prefilters.
   2. Provide one container of red oil for inclined manometer filter gage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   1. Air Filters:
      a) AAF International.
      b) Airguard Industries, Inc.
      c) Barnebey & Sutcliffe Corp.
      d) Columbus Industries, Inc.
      e) Continental Air Filter Div.; NiCon Filter Corp.
      f) Farr Co.
      g) Flanders Filters, Inc.
      h) International Air Filter, Inc.
      i) Koch Filter Corp.

j) Research Products Corp.

2.2 DISPOSABLE PANEL FILTERS

A. Description: Factory-fabricated, viscous-coated, flat-panel type, disposable air filters with holding frames.

B. Media: Interlaced glass fibers sprayed with nonflammable adhesive for 30% efficiency.

C. Frame: Cardboard frame with perforated metal retainer.

D. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

E. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Coordinate filter installations with duct and air-handling unit installations.

E. Electrical wiring and connections are specified in Division 16 Sections.

3.2 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 40 00

SECTION 237313 - MODULAR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract,

A. Drawings and general provisions of the Contract, including Scope of Work Section, apply to this Section.

B. Requirements of the following Division 24 Sections apply to this section:

1. "Basic Mechanical Requirements."
2. "Basic Materials and Methods."

1.2 SUMMARY

A. This Section includes central-station air-handling units with coils for indoor installations for constant-volume and variable volume application.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each central-station air-handling unit indicated, including the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound power ratings.
3. Certified coil performance ratings with system operating conditions indicated.
4. Motor ratings and electrical characteristics plus motor and fan accessories.
5. Materials thicknesses and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings, linkages, and operators.

C. Shop drawings from manufacturer detailing dimensions, required clearances, components, and location and size of each field connection.

D. Wiring diagrams detailing wiring for power and controls and differentiating between manufacturer-installed wiring and field- installed wiring.

E. Maintenance data for central-station air-handling units for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 21 Section "Basic Mechanical Materials and Methods."

1.4 QUALITY ASSURANCE

A. NFPA Compliance: Central-station air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA Standard 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. ARI Certification: Central-station air-handling units and their components shall be factory tested in accordance with the applicable portions of ARI 430 - Standard for Central-Station Air-Handling Units and shall be listed and bear the label of the Air-Conditioning

and Refrigeration Institute.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Lift and support units with the manufacturer's designated lifting or supporting points.

B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

C. Deliver central-station air-handling units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the size and location of concrete equipment pads. Cast anchor bolt inserts into pad.

B. Coordinate the size and location of structural steel support members.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. General Description: Factory assembled, consisting of fans, motor and drive assembly, coils, damper, filters, and drip pans. Units shall be shipped to site in splits of a size that can be passed through an 8' Wide by 8' High double door. Unit shall be assembled in the assigned room per the manufacturers instructions.

B. Types: Central-station air-handling units included in this project are of the following types:

1. Vertical Draw-through.
2. Horizontal Draw-through.

C. Motor and Electrical Components: Refer to Division 23 Section "COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT" Motors to be suitable for use with Variable Frequency Drive Units.

2.2 CABINET

A. Materials: Formed and reinforced double-wall, insulated galvanized steel panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

1. Outside Casing: Galvanized steel
2. Inside Casing: Galvanized steel, perforated.
3. Floor Plate: Galvanized steel.

B. Cabinet Insulation: Comply with NFPA Standard 90A "Standard for the Installation of Air Conditioning and Ventilating Systems," for insulation. Insulation exposed to the airstream is not allowed.

1. Type: Glass-fiber insulation, 1 inch (25 mm) thick and having a minimum density of 1-1/2 pcf (24 kg/cu m).

2. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.

3. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from and including the cooling coil section.

4. Location and Application: Encased between outside and inside casing.

C. Access Panels and Doors: Same materials and finishes as cabinet and complete with hinges, latches, handles, and gaskets.

1. Fan section shall have inspection and access panels and doors sized and located to allow periodic maintenance and inspections.

D. Single-Wall Drain Pans: Formed sections of Type 304 Stainless Steel. Fabricate pans in sizes, shapes and slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at the maximum cataloged face velocity across the cooling coil.

2.3 FANS SECTION

A. Testing Requirements: The following factory tests are required:

1. General: Sound power level ratings shall comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data" and shall be the result of tests made in accordance with AMCA Standard 300 "Test Code for Sound Rating." Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.

2. Unit's fans performance ratings for flow rate, pressure, power, air density, speed of rotation, and efficiency shall be factory tested and ratings established in accordance with AMCA Standard 210/ASHRAE Standard 51 - Laboratory Methods of Testing Fans for Rating.

B. Fan Section Construction: Fan section shall be equipped with a formed steel channel base for integral mounting of fan, motor, and casing panels. The fan scroll, wheel, shaft, bearings, and motor shall be mounted on a structural steel frame with frame mounted on base with vibration isolators.

C. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower. Fan wheel shall be double-width, double-inlet type with forward-curved blades or backward-curved airfoil section blades as indicated. Forward-curved blade wheels shall be galvanized steel or bonderized steel painted with baked-enamel finish. Airfoil wheels shall be steel painted with zinc chromate primer and an enamel finish coat. Fan shaft shall be solid steel, turned, ground, and polished. Fan wheels shall be keyed to the shaft.

D. Shaft Bearings: Grease-lubricated ball bearings selected for 200,000 hours' average life, with grease fittings extended to an accessible location outside the fan section.

E. Fan Drives: Designed for a 1.4 service factor and factory mounted with final alignment and belt adjustment made after installation.

1. Belt Drive: Motors and fan wheel pulleys shall be adjustable pitch for use with motors up to and including 15 HP and fixed pitch for use with motors larger than

15 HP.

2.4 MOTORS

A. Torque Characteristics: Sufficient to accelerate the driven loads satisfactorily.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so that the driven load will not require the motor to operate in the service factor range.

C. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation).

D. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.

E. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design B. Suitable for Variable Frequency Drive Applications.

1. Bases: Adjustable.
2. Bearings: The following features are required:
   a. Ball or roller bearings with inner and outer shaft seals.
   b. Grease lubricated.
   c. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
3. Enclosure Type: The following features are required:
   a. Open drip-proof motors where satisfactorily housed.
4. Overload protection: Built-in, automatic reset, thermal overload protection.
5. Noise rating: Quiet.
6. Efficiency: Energy-efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, Test Method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112, Test Method B.
7. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, and special features.

F. Variable Frequency Drive. Motor shall be suitable to operate with a Variable Frequency Drive in accordance with Section 23 06 01 Variable Frequency Controller.

F. Starters, Electrical Devices, and Wiring: Replace thermal overload for existing starter per motor nameplate full load amperes. Electrical devices and connections are existing, see electrical drawings for extends of work required.

2.5 COILS

A. Testing Requirements: The following factory tests are required:

1. Coil Performance Tests: Cooling and heating coils shall be factory tested for rating in accordance with ARI 410 - Standard for Forced-Circulation Air- Cooling and Air-Heating Coils.

B. Coil Sections: Common or individual insulated, galvanized steel casings for heating and cooling coils. Coil section shall be designed and constructed to facilitate removal of coil for maintenance and replacement and to assure full air flow through coils.

1. Medium-pressure units shall have double gaskets between sections and coil

connection penetrations through casing sealed to minimize leakage.

C. Coils, General: Drainable, rigidly supported across the full face of the coil, and pitched to allow drainage.

1. Fins: Aluminum or copper, constructed from flat plate with belled collars for tubes. Fins shall be bonded to tubes by mechanically expanding copper tubes.
2. Fin Spacing: Maximum 11 Fins Per Inch.
3. Rows: Minimum 6 Row.
2. Tubes: Seamless copper.
3. Coil Casing: Galvanized steel.
4. Headers for Water Coils: Steel or cast iron, with connections for drain valve and air vent and threaded piping connections.
5. Water Coil Turbulators: Bronze, spring-type.

2.6 DAMPERS

A. General: Leakage rate when tested in accordance with AMCA Standard 500 - Test Method for Louvers, Dampers and Shutters, shall not exceed 2 percent of air quantity calculated at 2,000 fpm (10 m/s) face velocity through damper and 4.0 inches w.g. (995 Pa) pressure differential.

1. Damper operators shall be pneumatically or electrically operated.

2.7 FILTERS

A. General: Filters shall comply with NFPA Standard 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Disposable Filters: Provide disposable type HEPA air filters, 24@ x 24@ x 18@ unit (3 per air handling unit), consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceeding 0.6 inch w.g. at face velocity of 300 fpm (1.52 m/s), and filter arrestance efficiency of 70 to 82 percent based on ASHRAE Test Standard 52 - Method of Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of central-station air- handling units.

B. Examine rough-in for hydronic, condensate drainage piping and electrical to verify actual locations of connections prior to installation.

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

3.2 INSTALLATION, GENERAL

A. Install central-station air-handling units level and plumb, in accordance with manufacturer's written instructions.

1. Support floor-mounted units on concrete equipment bases using neoprene pads.

Secure units to anchor bolts installed in concrete equipment base.

B. Arrange installation of units to provide access space around air- handling units for service and maintenance.

3.3 EQUIPMENT BASES

A. Construct concrete equipment pads as follows:

1. Coordinate size of equipment bases with actual unit sizes provided. Construct base 4 inches (100 mm) larger in both directions than the overall dimensions of the supported unit.
2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
4. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C 150, 4,000 psi (30 MPa) compressive strength, and normal weight aggregate.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. The following are specific connection requirements:

1. Arrange piping installations adjacent to units to allow unit servicing and maintenance.
2. Connect condensate drain pans using 1-1/4 inch, Type M (DN32, Type C) copper tubing. Extend to the nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

B. Duct installations and connections are specified in other Division 23 sections. Make final duct connections with flexible connections.

C. Electrical Connections: The following requirements apply:

1. Electrical power wiring is specified in Division 24.
2. Grounding: Connect unit components to ground in accordance with the National Electrical Code

3.5 ADJUSTING, CLEANING, AND PROTECTING

A. Adjust water coil flow, with control valves to full coil flow, to indicated gpm flow rates.

B. Adjust damper linkages for proper damper operation.

C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face.

D. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters

3.6 FIELD QUALITY CONTROL

Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water and with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Fan 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.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

STARTUP SERVICE

Engage a factory-authorized service representative to perform startup service.

Final Checks before Startup: Perform the following:

Verify that shipping, blocking, and bracing are removed.
Verify that unit is secure on mountings and supporting devices and connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
Perform cleaning and adjusting specified in this Section.
Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
Set outside- and return-air mixing dampers to minimum outside-air setting.
Comb coil fins for parallel orientation.
Install clean filters.
Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

Starting procedures for modular indoor air-handling units include the following:

Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
Measure and record motor electrical values for voltage and amperage.
Manually operate dampers from fully closed to fully open position and record fan performance.

.DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain modular indoor air-handling units.

END OF SECTION 23 73 13